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THE COMPLETE MEASURER: OR, THE Whole Art of Measuring.

IN TWO PARTS.

The First PART teaching

DECIMAL ARITHMETICK, with the *Extraction* of the SQUARE and CUBE ROOTS:

And also the *Multiplication of Feet and Inches*, commonly called CROSS MULTIPLICATION.

The Second PART teaching to

Measure all Sorts of SUPERFICIES and SOLIDS, by *Decimals*; by *Cross Multiplication*, and by *Scale* and *Compasses*: Also the Works of several Artificers relating to *Building*; and the Measuring of *Board* and *Timber*. Shewing the common Errors.

And some *Practical* QUESTIONS.

The *Fourteenth* EDITION. To which is added, An APPENDIX. 1, *Of* Gauging. 2. *Of* Land-Measuring.

Very useful for all Tradesmen; especially Carpenters, Bricklayers, Plaisterers, Painters, Joyners, Glasiers, Masons, &c.

By WILLIAM HAWNEY, *Philomath*.

Recommended by the Rev. Dr. John Harris, *F. R. S.*

LONDON:

Printed for J. and F. RIVINGTON, L. HAWES and W. CLARKE and R. COLLINS, R. HORSFIELD, T. CASLON, G. KEITH, S. CROWDER, T. LONGMAN, B. LAW, J. WILKIE, S. BLADON, G. ROBINSON, W. STUART, and R. BALDWIN. 1775.

D,

I Have perused this BOOK, and recommend it to the Publick as a very useful One.

J. HARRIS, *D. D.*

Lately published, the Second Edition of

The Doctrine of PLAIN and SPHERICAL TRIGONOMETRY; with its Use in various Branches of the MATHEMATICKS.

By *W. Hawney*, Author of this Book.

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Pardie's Short but yet Plain ELEMENTS of GEOMETRY; shewing by a brief and easy Method how most of what is Necessary and Useful in this Science, may be understood. Translated by the above-mentioned Dr. *Harris*, and referred to in the Preface of this Book.

THE PREFACE.

HAVING perused several Books concerning the Mensuration of Superficies and Solids, and the Works of Artificers relating to Building; but not finding any one Book so perfect, as to give any tolerable Satisfaction to a Learner; and I having practised and taught Measuring for several Years, and thereby gained Experience and Knowledge in that Art, having learned some Things from one Author, and some Things from another, I began to think of digesting my Thoughts into some such Method as might give a Learner full Satisfaction, without being at the Charge of buying so many Books; and being importuned thereunto by some Friends, I fell to work, and at last brought them to that Perfection you here find in the following Work.

1. As to the *Decimal Arithmetick*, I have been as plain as the Matter would well bear, to make it plain.

 2. As

2. As to the Multiplying of Feet and Inches, commonly called *Cross Multiplication*, my Method differs from that which is usually taught in other Authors, as being (I think) much shorter and plainer.

3. In measuring of Superficies and Solids, I have given the Demonstration of the Rules, which I thought might be very acceptable to the Ingenious; for, indeed, I always look upon the Writing of a Rule without a Demonstration (in any Part of the Mathematicks) to be but lame and defective; and for want of knowing the Reason of the Rule, a Learner may commit great Errors; besides, when a Learner knows the Reason of the Rules, he may retain them better in his Memory. The Rule for measuring a Prismoid and Cylindroid, I had out of Mr. *Everard*'s *Art of Gauging*; but the Reason he does not shew, neither have I found it in any other Author; but that the Method is true, I have endeavoured to make plain.

The Demonstration of the Rules for finding the Area of an Ellipsis and Parabola; also the Demonstration of the Rules for finding the solid Content of the Frustum of a Cone and Pyramid, the Solidity of a Globe of a Spheroid, a Parabolic Conoid, and of a Parabolic Spindle, and their Frustums, I had from the ingenious Mr. *Ward*'s *Young Mathematician's Guide*; where the curious and ingenious Reader may see many other Demonstrations algebraically performed. I have also demonstrated the Rule for finding the Solidity of a Globe, out of *Pardie*'s *Elements of Geometry* (Book the 5th, Art. the 33d) published in *English* with many Additions,

Additions, by the Reverend Dr. *Harris*, F. R. S. and the same is also done out of *Sturmius*'s *Mathesis Enucleata*; so that the ingenious Reader may use which of those Ways he likes best.

The Scale supposed to be used in all the Operations, is the Line of Numbers, commonly called *Gunter's Line*, which is upon the ordinary Two-Feet or Eighteen-Inch Rules, commonly used by the Carpenters, Masons, &c. because I thought it needless, as well as impertinent, to write the Use of Sliding-Rules, or any other particular Scales, they being sufficiently treated of by several Authors; *viz.* by the above-named Mr. *Everard*, in his *Art of Gauging* above-mentioned; where you have the Use of a Sliding-Rule in Arithmetick, Geometry, in Measuring of Superficies and Solids, Gauging, &c. Likewise Mr. *Hunt* has written largely of the Uses of his Sliding-Rule, in Arithmetick, Geometry, Trigonometry, Gauging, Dialling, &c. There are several others who have explained the Use of their own Rules; so that the more curious Readers may find full Satisfaction in those Authors.

One Thing I have omitted in the Book, which I think may not be very improperly inserted in this Place; that is, how to find a Number upon the Line. If the Number you would find consists only of Units, then the Figures upon the Line represent the Number sought: Thus, if the Number be 1, 2, 3, &c. then 1, 2, 3, &c. upon the Line, represents the Number sought. But if the Number consists of two Figures, that is, of Units and Tens, then the Figure upon the Rule stands for

the Tens, and the large Divisions stand for the Units; thus, if 34 were to be found upon the Line, the Figure 3 upon the Line is 30, and 4 of the large Divisions (counted forwards) is the Point representing 34; and if 340 were to be found, it will be at the same Point upon the Line; and if 304 were to be found, then the 3 upon the Line is 300, and four of the smaller Divisions (counted forward) is the Point representing 304. If the Number consists of four Places, or Thousands, then the Figure upon the Line stands for Thousands, and the larger Divisions are Hundreds, the lesser Divisions are Tens, and the tenth Parts of those lesser Divisions are Units. Thus, if 2735 were to be found, then the 2 is 2000; and the 7 larger Divisions (counted forward) is 700 more; and 3 of the lesser Divisions is 30 more; and half of one of the lesser Divisions is 5 more, which is the Point representing 2735. You must remember, that between each Figure upon the Line there are 10 Parts, which I call the larger Divisions; and each of those larger Divisions are subdivided (or supposed so to be) into 10 other Parts, which I call the smaller Divisions; and each of those Parts supposed to be subdivided again into ten other Parts, *&c.* You must also remember, that if 1 in the Middle of the Line stands only for 1, then 1 at the upper End will be 10, and 1 at the lower End will only be $\frac{1}{10}$; but if 1 at the lower End signifies 1, then 1 in the Middle stands for 10, and 1 at the upper End is 100, *&c.*

There is one Thing more which I would have my Reader to understand; and that is, how to find

all

all such proportional Numbers made use of in the Proportions about a Circle, and of a Cylinder, and in other Places; which Thing may be of good Use to know how to correct a Number, which may happen to be false printed, or to enlarge any Number to more decimal Places, for more Exactness; for though I have mentioned what such Numbers are, yet I have not shewn how to find them, which a Learner may be a little at a Nonplus to do; though they are easily found by the Rules there laid down. I shall therefore give two or three Examples, in this Place, of finding such Numbers, which may enable my Reader to find out the rest.

And, first, let it be required to find the Area of a Circle, whose Diameter is an Unit.

By the Proportion of *Van Culen*, if the Diameter be 1, the Circumference will be 3.1416926, &c. whereof 3.1416 is sufficient in most Cases. Then the Rule teaches to multiply half the Circumference by half the Diameter, and the Product is the Area: That is, multiply 1.5708 by .5 (*viz.* half 3.1416 by half 1) and the Product is .7854, which is the Area of the Circle, whose Diameter is 1.

Again; if the Area be required when the Circumference is 1; first find what the Diameter will be, thus: 3.1416 : to 1 : : so is 1, to .318309; which is the Diameter when the Circumference is 1. Then multiply half .318309 by half 1; that is .159154 by .5, and the Product is .079577, which is the Area of a Circle whose Circumference is 1.

If

If the Area be given, to find the Side of the Square equal, you need but extract the Square Root of the Area given, and it is done: So the Square Root of .7854 is .8862, which is the Side of a Square equal when the Diameter is 1. And if you extract the Square Root of .079577, it will be .2821, which is the Side of the Square equal to the Circle whose Circumference is 1.

If the Side of a Square within a Circle be required; if you square the Semidiameter, and double that Square, and out of that Sum extract the Square Root, that shall be the Side of the Square which may be inscribed in that Circle; so if the Diameter of the Circle be 1, then the half is .5; which squared, is .25; and this, doubled, is 5, whose Square Root is .7071, the Side of the Square inscribed.

Again; If the Diameter of a Globe be 1, to find the Solidity. In Sect. XI. Chap. II. it is demonstrated, that the Globe is $\frac{2}{3}$ of a Cylinder of the same Diameter and Altitude: Thus, if the Cylinder's Diameter be 1, and its Altitude or Length be also 1, find the Solidity thereof, and take $\frac{2}{3}$ of it, and that will be the Solidity of the Globe required. Now if the Diameter be 1, the Area of the Circle, or Base of the Cylinder, is .7854 (as is above shewn) which multiplied by 1, the Altitude of the Cylinder, and the Product is also .7854, the Solidity of the Cylinder; $\frac{2}{3}$ whereof is .5236, which is the Solidity of the Globe, whose Diameter is 1.

From

From what has been ſaid, the Reader may eaſily perceive how all other proportional Numbers are found, and may examine them at his Pleaſure.

I ſhall not enlarge any farther upon the Matter, but leave the Book to ſpeak for itſelf; and if it prove beneficial to the ingenious Practitioners, I have my Deſire. So, wiſhing my ingenious Reader good Succeſs in his Endeavours, not doubting but he will reap Profit hereby; which that he may, is the hearty Deſire of his Well-wiſher,

W. HAWNEY.

THE

THE

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THE

THE
Complete MEASURER.

PART I.

CHAP. I.

Notation of DECIMALS.

A DECIMAL Fraction is an artificial Way of setting down and expressing of Natural or Vulgar Fractions, as whole Numbers: And whereas the Denominators of Vulgar Fractions are divers, the Denominators of Decimal Fractions are always certain: For a Decimal Fraction hath always for its Denominator an Unit, with a Cypher or Cyphers annexed to it, and must therefore be either 10, 100, 1000, 10000, *&c.* and therefore in writing down of a Decimal Fraction, there is no Necessity of writing down the Denominator; for by bare Inspection it is certainly known, consisting of an Unit with as many Cyphers annexed to it as there are Places (or Figures) in the Numerator.

Example. This Decimal Fraction $\frac{25}{100}$ may be written thus .25, its Denominator being known to be an Unit with two Cyphers; because there are two Figures in the Numerator. In like manner, $\frac{125}{1000}$ may be thus written, .125; and $\frac{3575}{10000}$ thus, .3575; and $\frac{75}{1000}$ thus, .075; and $\frac{65}{10000}$ thus, .0065.

As whole Numbers increase in a decuple or ten-fold Proportion, towards the Left-hand, so, on the contrary, Decimals decrease towards the Right-hand in a decuple Proportion, as in the following Scheme.

Tens of Millions.	Millions.	Hundreds of Thousands.	Tens of Thousands.	Thousands.	Hundreds.	Tens.	Units.	Tenth Parts.	Hundredth Parts.	Thousandth Parts.	Ten Thousandth Parts.	Hundred Thousandth Parts.	Millionth Parts, &c.
7	6	5	4	3	2	1	0	1	2	3	4	5	6

Hence it appears, that Cyphers put on the Right-hand of whole Numbers, do increase the Value of those Numbers in a decuple (or ten-fold) Proportion: But being annexed to the Right-hand of a Decimal Fraction, do neither increase nor decrease the Value thereof: So $\frac{2500}{10000}$ is equivalent to $\frac{025}{100}$ or .25. And, on the contrary, tho' in whole Numbers, Cyphers prefixed before them, do neither increase nor diminish the Value; yet Cyphers before a decimal Fraction do diminish its Value in a decuple Proportion: For .25, if you prefix a Cypher before it, becomes $\frac{025}{1000}$ or .025: And .125 is $\frac{00125}{100000}$, by prefixing two Cyphers before it, thus, 00125. And therefore, when you are to write a decimal Fraction, whose Denominator hath more Cyphers than there are Figures in the Numerator,

merator, they must be supplied by prefixing so many Cyphers before the Figures of your Numerator; as, suppose $\frac{19}{1000}$ were to be written down, without its Denominator; here, because there are three Cyphers in the Denominator, and but two Figures in the Numerator, therefore prefix a Cypher before 19, and set it down thus, .019.

The Integers are separated from the Decimals several Ways, according to Mens Fancies; but the best and most usual Way is by a Point or Period; and if there be no whole Number, then a Point before the Fraction is sufficient: Thus, if you were to write down 317 $\frac{217}{1000}$ it may be thus expressed, 317.217; and 59 $\frac{25}{10000}$ thus, 59.0025; and $\frac{75}{10000}$ thus, .0075, &c.

CHAP. II.

Reduction of DECIMALS.

IN *Reduction of Decimals*, there are three Cases: 1st, To reduce a Vulgar Fraction to a Decimal. 2dly, To find the Value of a Decimal in the known Parts of Coin, Weights, Measures, &c 3dly, To reduce Coin, Weights, Measures, &c. to a Decimal. Of these in their Order.

I. *To reduce a Vulgar Fraction to a Decimal.*

The RULE.

As the Denominator of the given Fraction is to its Numerator, so is an Unit (with a competent Number of Cyphers annexed) to the Decimal required.

Therefore, if to the Numerator given, you annex a competent Number of Cyphers, and divide the Re-

sult by the Denominator, the Quotient is the Decimal equivalent to the Vulgar Fraction given.

Example 1. Let $\frac{3}{4}$ be given, to be reduced to a Decimal of two Places, or having 100 for its Denominator.

To 3 (the Numerator given) annex two Cyphers, and it makes 300; which divide by the Denominator 4, and the Quotient is .75, the Decimal required, and is equivalent to $\frac{3}{4}$ given.

Note, That so many Cyphers as you annex to the given Numerator, so many Places must be pricked off in the Decimal found; and if it should happen, that there are not so many Places of Figures in the Quotient, the Deficiency must be supplied, by prefixing so many Cyphers before the Quotient Figures, as in the next Example.

Example 2. Let $\frac{3}{573}$ be reduced to a Decimal having six Places.

To the Numerator annex six Cyphers, and divide by the Denominator, and the Quotient is 5235; but it was required to have six Places, therefore you must prefix two Cyphers before it, and then it will be 005235, which is the Decimal required, and is equivalent to $\frac{3}{573}$.

See the Work of these two Examples.

```
4)3.00(.75        573)3.000000(005235
  28                    ....
  ——                   ——————
  20                   1350
  20                    2040
  ——                     3210
  ..                    ——————
                          345
```

In the second Example there remains 345, which Remainder is very insignificant, it being less than $\frac{1}{1000000}$ Part of an Unit, and therefore is rejected.

II. To

II. *To find the Value of a Decimal in the known Parts of Money, Weight, Measures, &c.*

The RULE.

Multiply the given Decimal by the Number of Parts in the next inferior Denomination, and from the Product prick off ſo many Places to the Right-hand as there were Places in the Decimal given; and multiply thoſe Figures pricked off by the Number of Parts in the next inferior Denomination, and prick off ſo many Places as before, and ſo continue to do, till you have brought it to the loweſt Denomination required.

Example 1. Let .7565 of a Pound Sterling be given to be reduced to Shillings, Pence, and Farthings.

Multiply by 20, by 12, and by 4, as the Rule directs, and always prick off four Places to the Right-hand, and you will find it make 15*s.* 1*d.* 2*q.* See the Work.

```
   .7565
      20
s. ------
 15.1300
      12
d. ------
  1.5600
       4
q. ------
  2.2400
```

A more compendious Way of finding the Value of the Decimal of a Pound Sterling.

Double the firſt Figure, (or Place of Primes) and it makes ſo many Shillings; and if the next Figure (or Place of Seconds) be 5, or more than 5, for the 5 add another Shilling to the former Shillings; then

for every Unit in the second Place count ten, and to that add the Figure in the third Place, and reckon that so many Farthings; but if they make above 13, abate 1; and if it be above 38, abate 2, and add the remaining Farthings to the Shillings before found.

Example 1. Let .695 of a Pound be reduced to Shillings, Pence, and Farthings.

First, Double your 6, and it makes it 12*s.* then take 5 out of 9, and for that reckon another Shilling, and it makes 13*s.* and the 4 remaining is four Tens, and the 5 makes 45, which being above 38, you must therefore cast away 2, and there rest 43 Farthings, which is 10*d.* ¾. So the Answer is 13*s.* 10*d.* ¾.

	l.	*s.*	*d.*
So the Value of .725	=	14	6
And the Value of .878	=	17	6¾
And the Value of .417	=	8	4

And so of any other.

Let .59755 of a Pound Troy be reduced to Ounces, Penny-weights, and Grains.

Multiply by 12, by 20, and by 24, and always prick off five Places towards the Right-hand, and you will find the Answer to be 7 *oz.* 3 *pwts.* 13 *g. fere.* See the Work.

.59755
12
———
7.17060
20 *oz. pwts. gr.*
——— *Facit* 7 3 9.888
24
———
164800
82400
———
9.88800

Let

Let .43569 of a Ton be reduced to Hundreds, Quarters, and Pounds.

Multiply by 20, by 4, and by 28, and the Answer will be 8 *C.* 2 *qrs.* 24 *lb.* *fere.*

```
.43569
    20
------
8.71380
      4            C. qrs. lb.
------ Facit 8   2   24.9456
2.85520
     28
------
23.94560
```

Let .9595 of a Foot be reduced into Inches and Quarters.

```
.9595
   12
------
11.5140
     4  Facit 11 Inches, 2 Quarters.
------
2.0560
```

III. *To reduce the known Parts of Money, Weight, Measure, &c. to a Decimal.*

The RULE.

To the Number of Parts of the lesser Denomination given, annex a competent Number of Cyphers, and divide by the Number of such Parts that are contained in the greater Denomination, to which the Decimal is to be brought; and the Quotient is the Decimal sought.

Example

Example 1. Let 6 *d.* be reduced to the Decimal of a Pound.

To 6 annex a competent Number of Cyphers (suppose 3), and divide the Result by 240 (the Pence in a Pound), and the Quotient is the Decimal required.

```
240)6.00|0(.025
    ----
    1200
    ----  Facit ,025
    ....
```

Example 2. Let 3 *d.* $\frac{3}{4}$ be reduced to the Decimal of a Pound, having six Places.

In 3 *d.* $\frac{3}{4}$ there are fifteen Farthings, therefore to 15 annex six Cyphers (because there are to be six Places in the Decimal required), and divide by 960 (the Farthings in a Pound), and the Quotient is .015625.

```
96|0)15.00000|0(.015625
         .....
         -----
         540
          600
           240
            480
           -----
            ...
```

Example 3. Let 3 $\frac{1}{4}$ Inches be reduced to the Decimal of a Foot, consisting of four Places.

In 3 $\frac{1}{4}$ Inches, there are 13 Quarters; therefore to 13 annex four Cyphers, and divide by 48 (the Quarters in a Foot), and the Quotient is .2708.

```
48)13.0000(2700
   --------
     340
      400
     ----
      16
```

Example 4. Let 9 *C.* 1 *qr.* 16 *lb.* be reduced to the Decimal of a Ton, having six Places.

C. qu. lb.	
9 1 16	2240)1052.00000|0(469642
4	
37 *qrs.*	15600
28	21600
	14400
302 *Facit* .469642	96000
75	6400
1052 Pounds.	1920

CHAP. III.

Addition of DECIMALS.

ADDITION of Decimals is performed the same Way as Addition of whole Numbers, only you must observe to place your Numbers right, that is, Units under Units, Primes under Primes, Seconds under Seconds, &c.

Example. Let 317.25, 17.125, 275.5, 47.3579, and 12.75, be added together into one Sum.

```
     317.25
      17.125
     275.5
      47.3579
      12.75
     --------
Sum  669.9829
```

This is so plain, that more Examples I think needless.

CHAP.

CHAP. IV.

Subtraction of DECIMALS.

SUBTRACTION of Decimals is performed likewise the same Way as in whole Numbers, respect being had to the right placing the Numbers (as in Addition), as in the following Examples.

	(1)		(2)
From	212.0137	From	201.1250
Subtr.	31.1275	Subtr.	5.5785
Rests	180.8862	Rests	195.5465
Proof	212.0137	Proof	201.1250

	(3)		(4)
From	2051.315	From	30.5
Subtr.	79.172	Subtr.	7.2597
Rests	1972.143	Rests	23.2403
Proof	2051.315	Proof	30.5

Note, If the Number of Places in the Decimals be more in that which is to be subtracted, than in that which you subtract from, you must suppose Cyphers to make up the Number of Places, as in the fourth Example.

CHAP. V.

Multiplication of DECIMALS.

MULTIPLCATION of Decimals is also performed the same Way as Multiplication of whole Numbers; but to know the Value of the Product, observe this Rule.

Cut off, or separate by a Comma or Prick, so many decimal Places in the Product, as there are Places in Decimals in both Factors, *viz.* in the Multiplicand and Multiplier; which I shall further explain in the following Examples.

Let 3.125 be multiplied by 2.75; multiply the Numbers together, as if they were whole Numbers, and the Product is 8.59375: And because there were three Places of Decimals pricked off in the Multiplicand, and two Places in the Multiplier, therefore you must prick off five Places of Decimals in the Product, as you may see by the Work.

```
 3.125
  2.75
------
 15625
21875
 6250
------
8.59375
```

Let

Let 79.25 be multiplied by .459.

In this Example, becaufe two Places of Decimals are pricked off in the Multiplicand, and three in the Multiplier, therefore there muft be five pricked off in the Product.

79.25
.459
71325
39625
31700
36.37575

Let .135272 be multiplied by .00425.

In this Example, becaufe in the Multiplicand are fix decimal Places, and in the Multiplier five Places; therefore in the Product there muft be eleven Places of Decimals; but when the Multiplication is finifhed, the Product is but 57490600, *viz.* only eight Places; therefore, in this Cafe, you muft prefix three Cyphers before the Product Figures, to make up the Number of eleven Places: So the true Product will be. 00057490600.

.135272
.00425
676360
270544
541088
.00057490600

More

More Examples for Practice.

.001472
.1045
―――――
7360
5888
14720
―――――
.0001538240

.017532
347
―――――
122724
70128
52596
―――――
6.083604

279.25
.445
―――――
139625
111700
111700
―――――
124.26625

32.0752
.0325
―――――
1603760
641504
962256
―――――
1.04244400

4.443
15.98
―――――
35544
39987
22215
4443
―――――
70.99914

20.0291
35.45
―――――
1001455
801164
1001455
600873
―――――
710.031595

7.3564
.0126
―――――
441384
147128
73564
―――――
.09269064

.75432
.0356
―――――
452592
377160
226296
―――――
.026853792

Contracted Multiplication of Decimals.

Because in Multiplication of Decimal Parts, and mixed Numbers, there is no need to express all the Figures of the Product, but in most Places two, three, or four Places of Decimals will be sufficient; therefore, to contract the Work, observe the following

RULE.

Write the Unit's Place of the Multiplier under that Place of the Multiplicand, whose Place you intend to keep in the Product; then invert the Order of all the other Figures; that is, write them all the contrary Way. Then, in multiplying, always begin at that Figure in the Multiplicand which stands over the Figure you are then multiplying withal, and set down the first Figure of each particular Product directly one under the other: But yet a due Regard must be had to the Increase arising from the Figures on the Right-hand of that Figure in the Multiplicand which you begin to multiply at. This will appear more plain by Examples.

Example 1. Let 2.38645 be multiplied by 8.2175, and let there be only four Places retained in the Decimals of the Product.

First, according to the Directions, write down the Multiplicand, and under it write the Multiplier, thus; place the 8 (being the Unit's Place of the Multiplier) under 4, the fourth Place of Decimals in the Multiplicand, and write the rest of the Figures quite contrary to the usual Way, as in the following Work: Then begin to multiply, first the 5 which is left out (only with regard to the Increase which must be carried from it); saying, 8 times 5 is 40; carry 4 in your Mind, and say, 8 times 4 is 32, and 4 I carry, is 36; set down 6, and carry 3, and proceed thro' the rest of the Figures as in common Multiplication:

 Then

Then begin to multiply with 2; saying, 2 times 4 is 8, for which I carry 1 (because it is above 5), and say, 2 times 6 is 12, and 1 that I carry is 13; set down 3, and carry 1, and proceed thro' the rest of the Figures: Then multiply with 1; saying, once 6 is 6, for which I carry 1, and say, once 8 is 8, and 1 is 9; set down 9, and proceed: Then multiply with 7; saying, 7 times 8 is 56, for which carry 6 (because it is above 55), and say, 7 times 3 is 21, and 6 that I carry is 27; set down 7, and carry 2, and proceed: Then multiply with 5; saying, 5 times 3 is 15, for which carry 2, and say, 5 times 2 is 10, and 2 I carry is 12, which set down, and add all the Products together; and the total Product will be 19.6107. See the Work.

```
  2.38645
  5712.8
  -------
  19.0916
    4773
     239
     167
      12
  -------
  19.6107
```

Note, That in multiplying the Figure left out every Time next the Right-hand in the Multiplicand, if the Product be 5, or upwards to 10, you carry 1; and if it be 15, or upwards to 20, carry 2; and if 25, or upwards to 30, carry 3, &c.

I have here set down the Work of the last Example, wrought by the common Way, by which you may see both the Reason and Excellency of this Way, all the Figures on the Right-hand of the Line being wholly omitted.

2.	38645
8.	2175
11	93225
167	0515
238	645
4772	90
190916	0
19.6106	52875

Example 2. Let 375.13758 be multiplied by 16.7324, so that the Product may have but four Places of Decimals.

First, set 6, the Unit's Place of the Multiplier, under 5, being the fourth Place of Decimals in the Multiplicand (because four Places of Decimals were to be pricked off), and write all the rest of the Figures backward. Then multiply all the Figures of the Multiplicand by 1, after the common Way. Then begin with the second Figure of the Multiplier 6; saying, 6 times 8 is 48, for which I carry 5 (in respect of the 8 left out), and 6 times 5 is 30, and 5 that I carry is 35; set down 5 and carry 3, and proceed after the common Method. Then begin with 7, the third Figure of the Multiplier, and say 7 times 5 is 35, for which carry 4, and say 7 times 7 is 49, and 4 I carry is 53; set down 3 under the first, and carry 5, and proceed as before. Then begin with 3, the fourth Figure of the Multiplier, and say 3 times 7 is 21, carry 2, and say 3 times 3 is 9, and 2 I carry is 11; set down 1 and carry 1, and proceed as before. Then begin with 2, the fifth Figure, and say 2 times 3 is 6, for which I carry 1, and say 2 times 1 is 2, and 1 I carry is 3; set down 3, and 2 times 5 is 10; set down 0, and carry 1, and proceed as before. Then begin with 4, the last Figure of the Multiplier, and say 4 times 1 is 4, for which I carry nothing, because it is less than 5: Then say 4 times

times 5 is 20; set down 0, and carry 2, and proceed thro' the rest of the Figures of the Multiplicand. Then add all up together, and the Product is 6276.9520. See the Work.

375.13758 the Multiplicand.
4237.61 the Multiplier reversed.

37513758 the Product with 1.
22508255 the Product with 6 increased with 6 × 8.
2625963 the Product with 7 increased with 7 × 5.
112541 the Product with 3 increased with 3 × 7.
7503 the Product with 2 increased with 2 × 3.
1500 the Product with 4 increased with 0.

6276.9520 the Product required.

Let the same Example be repeated, and let only one Place in Decimals be pricked off.

375.13758 the Multiplicand.
4237.61 the Multiplier reversed.

37514 the Product by 1 with the Increase of 1 × 7.
22508 the Product with 6 increased with 6 × 3.
2626 the Product with 7 increased with 7 × 1.
113 the Product with 3 increased with 3 × 5.
7 the Product with 2 increased with 2 × 7.
1 the Increase only of 4 × 3.

6276.9 the Product is the same as before.

More Examples for Practice.

Multiply 395.3756 by .75642; and prick off four Places in Decimals.

395.3756	the Multiplicand.
24657.	the Multiplier reverſed.
2767629	the Product by 7 increaſed with 7 × 6.
197688	the Product by 5 increaſed with 5 × 5.
23722	the Product by 6 increaſed with 6 × 7.
1581	the Product by 4 increaſed with 4 × 3.
76	the Product by 2 increaſed with 2 × 5.
299.0699	the Product required.

Let the ſame Example be repeated, and let there be only one Place of Decimals.

395.3756	
24657.	
2767	the Product by 7 increaſed with 7 × 3.
198	the Product by 5 increaſed with 5 × 5.
24	the Product by 6 increaſed with 6 × 9 + 6 × 5.
2	the Increaſe of 4 × 9 + 4 × 3.
299.1	the Product.

Characters,

Characters, and their Signification.

Note, That this Mark + signifies Addition; as 8+5, that is, 8 more 5, or 8 added to 5; and 8+3+7, denotes these Numbers are to be added into one Sum.

This Mark — signifies Subtraction, as 9—4 signifies that 4 is to be taken from 9.

This Mark × signifies Multiplication, as 7 × 5 signifies that 7 is to be multiplied by 5.

This Mark ÷ signifies Division, as 12 ÷ 4 signifies 12 is to be divided by 4.

This Mark = signifies Equality, or Equation; that is, when = is placed between Numbers, or Quantities, it denotes them to be equal, as 7 + 5 = 12, that is, 7 more 5 is equal to 12; and 15 — 7 = 8, that is, 15 less by 7, is equal to 8, or subtract 7 from 15, and there remains 8.

This Mark :: is the Sign of Proportion, or the Golden Rule, it being always placed betwixt the two middle Terms or Numbers in Proportion; thus 4 : 20 :: 6 : 30, to be thus read, as 4 is to 20, so is 6 to 30.

CHAP. VI.

Division of DECIMALS.

DIVISION of Decimals is performed after the same Manner as Division of whole Numbers; but to know the Value or Denomination of the Quotient, is the only Difficulty; for the resolving of which, observe either of the following

RULES.

RULES.

I. The first Figure in the Quotient must be of the same Denomination with that Figure in the Dividend which stands (or is to be supposed to stand) over the Unit's Place in the Divisor, at the first seeking.

II. When the Work of Division is ended, count how many Places of Decimal Parts there are in the Dividend more than in the Divisor; for that Excess is the Numbrr of Places which must be separated in the Question for Decimals: But if there be not so many Figures in the Quotient as is the said Excess, that Deficiency must be supplied with Cyphers in the Quotient, prefixed before the significant Figures thereof, towards the Left-hand, with a Point before them; so shall you plainly discover the Value of the Quotient.

These following Directions ought also to be carefully observed.

If the Divisor consists of more Places than the Dividend, there must be a competent Number of Cyphers annexed to the Dividend, to make it consist of as many (at least) or more Places of Decimals than the Divisor; for the Cyphers added must be reckoned as Decimals.

Consider whether there be as many Decimal Parts in the Dividend as there are in the Divisor; if there be not, make them so many, or more, by annexing of Cyphers.

In dividing of whole or mixed Numbers, if there be a Remainder, you may bring down more Cyphers; and, by continuing your Division, carry the Quotient to as many Places of Decimals as you please.

These Things being considered, I shall proceed to the Practice of Division of Decimals, which I shall endeavour to explain in as familiar and easy a Method as possible.

Example

Example 1. Let 48 be divided by 144.

In this Example the Divisor 144 is greater than the Dividend 48; therefore, according to the Directions above, I annex a competent Number of Cyphers (*viz.* four), with a Point between them, and divide according to the usual Way.

```
144)48.0000(.3333
    -------
     480
      480
       480
    -------
       48
```

But, first, in seeking how often 144 in 48.0 (the first three Figures of the Dividend), I find the Unit's Place of the Divisor to fall under the first Place of Decimals; therefore the first Figure in the Quotient is in the first Place of Decimals: Or, by the second Rule, there being four Places of Decimals in the Dividend, and none in the Divisor; so the Excess of decimal Places in the Dividend, above that in the Divisor, is four; so that when the Division is ended, there must be four Places of Decimals in the Quotient. See the Work.

Example 2. Let 217.75 be divided by 65.

First, in seeking how often 65 in 217 (the first three Figures of the Dividend), I find the Unit's Place of the Divisor to fall under the Unit's Place of the Dividend; therefore the first Figure in the Quotient will be Units, and all the rest Decimals: Or, by the second Rule, there being two Places of Decimals in the Dividend, and no Decimals in the Divisor, therefore the Excess of Decimal Places in the Dividend, above the Divisor, is two; so when the Division is ended, separate two Places in the Quotient, towards the Right hand by a Point. See the Work.

65)

```
65)217.75(3.35
     . . .
   --------
     227
      325
     -----
      . . .
```

Example 3. Let 267.15975 be divided by 13.25.

```
13.25)267.15975(20.163
         . . . . .
      ----------
       2159
        8347
         3975
       ------
        . . . .
```

In this Example, 3, the Unit's Place of the Divisor, falls under 6, the Ten's Place of the Dividend; therefore (by the first Rule) the first Figure in the Quotient is Tens: Or, by the second Rule, the Excess of Decimal Places in the Dividend, above the Divisor, is three; there being five Places of Decimals in the Dividend, and but two in the Divisor, so there must be three Places of Decimals in the Quotient.

Example 4. Let 15.675159 be divided by 375.89.

```
375.89)15.675159(.0417
               . .
          --------
           63955
           263669
          --------
              546
```

In

In this Example, 5, in the Unit's Place of the Divisor, falls under 7, the second Place of Decimals in the Dividend; therefore (by the first Rule) the first Figure in the Quotient is in the second Place of Decimals; so that you must put a Cypher before the first Figure in the Quotient; and by the second Rule, the Excess of decimal Places in the Dividend above the Number of decimal Places in the Divisor is 4; for the decimal Places in the Dividend is 6, and the Number of Places in the Divisor but two; therefore there must be four Places of Decimals in the Quotient: But the Division being finished after the common Way, the Figures in the Quotient are but three; therefore you must prefix a Cypher before the significant Figures.

Example 5. Let 72.1564 be divided by .1347.

```
.1347)72.1564(535.68
        ...
      ------
       4806
        7654
         9190
          11080
        ------
          304
```

In this Example, the Divisor being a Decimal, the first Figure thereof falls under the Ten's Place in the Dividend, therefore the Units (if there had been any) should fall under the Hundred's Place in the Dividend, and so the first Figure in the Quotient is Hundreds. And, by the second Rule, there being four Places of Decimals in the Dividend, and as many in the Divisor, so the Excess is nothing; but in dividing I put two Cyphers to the Remainders, and continue the Division to two Places further; so I have two Places of Decimals. See the Work.

Example

Example 6. Let .125 be divided by .0457.

```
.0457).1250000(2.735
            ....
     ----------
        914
        ---
        3360
        3199
        ----
         1610
         1371
         ----
          3390
          2285
          ----
           105
```

In this Example, the Unit's Place of the Divisor (if there had been any) would fall under the Unit's Place of the Dividend; therefore the first Figure of the Quotient is Units. And, by the second Rule, there being seven Places of Decimals in the Dividend, and but four Places in the Divisor, so the Excess is three; therefore there must be three Places of Decimals in the Quotient.

I shall set down only the Work of some few Examples more, and so proceed to *Contracted Division*.

```
.00456).0000059791(.00131
                  ..
             ------
             1419
              511
             ----
               55
```

Let

Let it be divided by 282.

282)1.0000000(.0035461 *fere*.

.....

1540
1300
1720
280

.325).400000(1.2307

...

750
1000
2500

225

.042)495.00000(11785.71

....

75
330
360
240
300
60

18

Division of DECIMALS *contracted.*

IN Division of Decimals the common Way, when the Divisor hath many Figures, and it is required to continue the Division till the Value of the Remainder be but small, the Operation will sometimes be large and tedious, but may be excellently contracted by the following Method.

The RULE.

By the first Rule of this Chapter (*Page* 20), find what is the Value of the first Figure in the Quotient; then, by knowing the first Figure's Denomination, you may have as many or as few Places of Decimals as you please, by taking as many of the Left-hand Figures of the Divisor as you think convenient for the first Divisor; and then take as many Figures of the Dividend as will answer them; and, in dividing, omit one Figure of the Divisor at each following Operation. A few Examples will make it plain.

Example 1. Let 721.17562 be divided by 2.257432; and let there be three Places of Decimals in the Quotient.

2.257432

```
2.25743)721 175|62)319.467
  .....  677229
         ------
         43946
         22574
         ------
         21372
         20317
         ------
          1055
           903
         ------
           152
           135
         ------
            17
            15
         ------
             2
```

In this Example, the Unit's Place of the Divisor falls under the Hundred's Place in the Dividend, and it is required, that three Places of Decimals be in the Quotient, so there must be six Places in all; that is, three Places of whole Numbers, and three Places of Decimals. Then, because I can have the Divisor in the first six Figures of the Dividend, I cut off the 62 with a Dash of the Pen, as useless; then I seek how often the Divisor is in the Dividend, and the Answer is three times; put 3 in the Quotient, and multiply and subtract as in common Division, and the Remainder is 43946. Then prick off the 3 in the Divisor, and seek how often the remaining Figures may be had in 43946, the Remainder, which can be but once; put 1 in the Quotient, and multiply and subtract, and the next Remainder is 21372. Then prick off the 4 in the Divisor, and seek how often the remaining Figures may be had in 21372, which will be 9 times; put 9 in the Quotient; multiply thus, saying 9

times 4 is 36, for which I carry 4 (in reſpect of the 4 laſt pricked off), and 9 times 7 is 63, and 4 is 67; ſet down 7, and carry 6, and ſo proceed till the Diviſion be finiſhed, always reſpecting the Increaſe made from the Figures pricked off. Obſerve the Work, which will better inform you than many Words.

```
2.25743)721.17562(319.467
                 ...
        677229|
        ------
         43946|6
         22574|3
        ------|-
         21372|32
         20316|87
        ------|---
          1055|450
           902|972
          ----|---
           152|4780
           135|4458
           ---|----
            17|03220
            15|80201
            --|-----
             1|23019
```

I have ſet down the Work of this laſt Example at large, according to the common Way, that thereby the Learner may ſee the Reaſon of the Rule, all the Figures on the Right Side the perpendicular Line being wholly omitted.

Example

Example 2. Let 5171.59165 be divided by 8.758615; and let it be required, that four Places of Decimals be pricked off in the Quotient.

```
8.758615)5171.5916|5(590.4577
 ••••••
         43793075
         --------
          7922841
          7882754
          -------
            40087
            35034
            -----
             5053
             4379
             ----
              674
              613
              ---
               61
               61
               --
               ••
```

In this Example, I can't have 8, the first Figure in the Divisor, in 5, the first Figure of the Dividend; so that the Unit's Place of the Divisor falls under the Hundred's Place of the Dividend; so that there will be seven Figures in the Quotient; that is, three of whole Numbers, and four of Decimals; therefore there must be seven Figures in the Divisor (because the Number of Places in the Divisor and Quotient will be equal), and there must be eight Places in the Dividend; so that I cut off the Figure 5 with a Dash, as useless. Thus having proportioned the Dividend to the Divisor, and both to the Number of Places or Figures desired in the Quotient, I proceed to divide as before; saying how often 8 in 51, which will be 5 times; put 5 in the Quotient, and multiply and sub-

tract, and the Remainder is 7922841. Then I prick off the first Figure in the Divisor, 5, and seek how often the remaining Figures of the Divisor in the aforesaid Remainder, which I find nine times; put 9 in the Quotient, and multiply thereby, saying 9 times 5 (the Figure pricked off) is 45, for which I carry 5, and say 9 times 1 is 9, and 5 I carry is 14; set down 4, and carry 1, and proceed to multiply the rest of the Figures, and subtract, and the Remainder will be 40087. Then prick off the Figure 1, and seek how often 87586 in the Remainder 40087, the Answer will be 0; so put 0 in the Quotient, and prick off the Figure 6, and seek how often 8758 in 40087, which will be four times; put 4 in the Quotient, and multiply, saying, 4 times 6 (the Figure last pricked off) is 24, for which I carry 2, and say 4 times 8 is 32, and 2 I carry is 34; set down 4, and carry 3; multiply the rest of the Figures, and subtract as before, and so proceed after the same manner, until all the Figures of the Divisor be pricked off, to the last Figure. See the Work.

Example 2. Let 25.1367 be divided by 217.3543, and let there be five Places of Decimals in the Quotient.

In this Example, 7, the Unit's Place of the Divisor, falls under 1, the first Place of Decimals; therefore the first Figure of the Quotient is in the first Place of Decimals; so the Quotient will be all Decimals. Then, because the Quotient Figures, and the Figures of the Divisor will be of an equal Number, dash off the 43 in the Divisor, and the 7 in the Dividend, as useless, and divide as before.

217.35|43

```
217.35|43)25.136|7(.11564
          21735
          -----
          3401
          2174
          ----
          1227
          1087
          ----
           140
           130
           ---
            10
             8
            --
             2
```

Altho' I have hitherto given Directions for proportioning the Divisor and Dividend, so as to bring into the Quotient what Number of Decimals you please, yet there is no absolute Necessity for it; but you may carry on your Division to what Degree you please, before you begin to prick off the Figures of the Divisor, in order to contract the Work, as in the following Examples, where it is not required to prick off any determinate Number of Decimals, but it may be done according to Discretion.

2.756756)7414.76717(2689.67118

5513512

19012551
16540536

24720157
22054048

2666109
2481080

185029
165405

19624
19297

327
276

51
28

23
22

1

```
12.34254)514.75498(41.705757
     ... 4937016
         -------
         2105338
         1234245
         -------
          871084
          863978
          ------
            7106
            6171
            ----
             935
             864
             ---
              71
              62
              --
               9
               8
               -
               1
```

CHAP. VII.

Extraction of the SQUARE ROOT.

If a Square Number be given;

TO find the Root thereof, that is, to find out such a Number, as being multiplied into itself, the Product shall be equal to the Number given; such Operation is called, *The Extraction of the Square Root*; which to do, observe the following Directions.

1ſt,

1*st*, You must point your given Number; that is, make a Point or Prick over the Unit's Place, another upon the Hundred's, and so upon every second Figure throughout.

2*dly*, Then seek the greatest square Number in the first Point towards the Left-hand, placing the square Number under the first Point, and the Root thereof in the Quotient, and subtract the said square Number from the first Point, and to the Remainder bring down the next Point, and call that the Resolvend.

3*dly*, Then double the Quotient, and place it, for a Divisor, on the Left-hand of the Resolvend; and seek how often the Divisor is contained in the Resolvend (reserving always the Unit's Place), and put the Answer in the Quotient, and also on the Right-hand Side of the Divisor; then multiply by the Figure last put in the Quotient, and subtract the Product from the Resolvend (as in common Division), and bring down the next Point to the Remainder (if there be any more), and proceed as before.

A TABLE *of* SQUARES *and* CUBES, *and their* ROOTS.

Root	1	2	3	4	5	6	7	8	9
Square	1	4	9	16	25	36	49	64	81
Cube	1	8	27	64	125	216	343	521	729

Example 1. Let 4489 be a Number given, and let the square Root thereof be required.

```
        4489.67
        36
        ------
    127.889 Resolvend.
        889 Product.
        ------
        • • •
```

First,

First, Point the given Number, as before directed; then, by the little Table aforegoing, seek the greatest square Number in 44 (the first Point to the Left-hand), which you will find to be 36, and 6 the Root; put 36 under 44, and 6 in the Quotient, and subtract 36 from 44, and there remains 8. Then to that 8 bring down the other Point 89, placing it on the Right-hand, so it makes 889 for a Resolvend; then double the Quotient 6, and it makes 12; which place on the Left-hand for a Divisor, and seek how often 12 in 88 (reserving the Unit's Place), the Answer is 7 times; which put in the Quotient, and also on the Right-hand Side of the Divisor, and multiply 127 by 7, as in common Division, and the Product is 889, which subtracted from the Resolvend, there remains nothing; so is your Work finished; and the square Root of 4489 is 67; which Root if you multiply by itself, that is 67 by 67, the Product will be 4489, equal to the given square Number, and prove the Work to be right.

Example 2. Let 106929 be a Number given, and let the square Root thereof be required.

```
  . . .
106929(.327
 9
 ------
62)169 Resolvend.
   124 Product.
   ------
647)4529 Resolvend.
    4529 Product.
    ----
    ....
```

First, Point your given Number, as before directed, putting a Point upon the Units, Hundreds, and Tens of Thousands; then seek what is the greatest square Number in 10 (the first Point), which by the little Table

Table you will find to be 9, and 3 the Root thereof; put 9 under 10, and 3 in the Quotient; then subtract 9 out of 10, and there remains 1; to which bring down 69, the next Point, and it makes 169 for the Resolvend; then double the Quotient 3, and it makes 6, which place on the Left-hand of the Resolvend for a Divisor, and seek how often 6 in 16; the Answer is twice; put 2 in the Quotient, and also on the Right-hand of the Divisor, making it 62. Then multiply 62 by the 2 you put in the Quotient, and the Product is 124; which subtract from the Resolvend, and there remains 45; to which bring down 29, the next Point, and it makes 4529 for a new Resolvend. Then double the Quotient 32, and it makes 64, which place on the Left Side of the Resolvend for the Divisor, and seek how often 64 in 452, which you'll find 7 times; put 7 in the Quotient, and also on the Right-hand of the Divisor, making it 647, which multiplied by the 7 in the Quotient, it makes 4529, which subtracted from the Resolvend, there remains nothing. So 327 is the Square Root of the given Number.

Example 3. Let 2268741 be a square Number given, the Root whereof is required.

```
          . . . .
          2268741)1506.23
          1
          -----
        25)126
           125
          -----
      3006)18741
           18036
          -----
     30122)70500
           60244
          -----
    301243)1025600
            903729
          -----
   Remains  121871
```

Having

Having pointed the given Number as before directed, ſeek what is the greateſt ſquare Number in the firſt Point 2, which is 1; put 1, the Square, under 2, and 1, the Root thereof, in the Quotient; ſubtract 1 from 2, and there remains 1; to which bring down the next Point, 26, and ſet on the Right-hand, making it 126; double the 1 in the Quotient; which makes 2; ſet 2 on the Left-hand for a Diviſor, and aſk how often 2 in 12, which will be 5 times; put 5 in the Quotient, and alſo on the Right-hand of the Diviſor, making it 25; multiply (as in common Diviſion) 25 by 5, and ſubtract the Product 125 from 126, and there remains 1; bring down the next Point, 87, and it makes 187 for a new Reſolvend; and double the 15 in the Quotient, it makes 30 for a new Diviſor. Then ſeek how often 30 in 18, which you can't have; ſo that you muſt put 0 in the Quotient, and alſo on the Right-hand of the Diviſor, and bring down the next Point, 41, and it makes 18741 for another new Reſolvend. Then ſeek how often 300 in 1874, which will be ſix times; put 6 in the Quotient, and alſo on the Right-hand of the Diviſor; multiply and ſubtract, and the Remainder will be 705. Now, if you have a Mind to find the Value of the Remainder, you may annex Cyphers, by two at a time, to the Remainders, and ſo proſecute the Work to what Number of decimal Parts you pleaſe; thus, to 705 annex two Cyphers, and it will make 70500, and the Quotient doubled, is 3012 for a Diviſor: Then ſeek how often 3012 in 7050 (rejecting the Unit's Place), which will be twice; put 2 in the Quotient, and alſo on the Right-hand of the Diviſor, and multiply and ſubtract as before, and the Remainder will be 10256; to which annex two Cyphers, and proceed as before, and you will get a 3 in the Quotient next. So the ſquare Root of the given Number is 1506.23, which being ſquared, or multiplied by itſelf, and the laſt Remainder added, will make the given Number as follows:

```
                    1506.23
                    1506.23
                   --------
                     451869
                    301246
                   903738
                  7531150
                 150623
                ----------------
                2268728.8129
The Remainder add    12.1871
                ----------------
          Proof 2268741.0000
```

Some more Examples for Practice.

```
Example 1.  7596796(2756.228 Root
            4
          ---
         47)359
            329
          -----
        545)3067
            2725
           -----
       5506)34296
            33036
           ------
      55122)126000
            110244
            -------
     551242)1575600
            1102484
            --------
    5512448)47311600
            44099584
            --------
             3212016
```

Example

```
                 .  .  .   .  .
*Example* 2.   751417.5745(866.4 Root.
               64
               ----
          166)1114
               996
               -----
         1726)11817
              10356
              ------
        17328)146157
              138624
              -------
       173364)753345
              693456
              ------
               59889
              ------
```

If the given Number be a mixed Number, *viz.* consisting of a whole Number and a Decimal together, make the Number of decimal Places even, that is, 2, 4, 6, 8, *&c.* that so there may a Point fall upon the Unit's Place of the whole Numbers, as in this last Example, and in that following.

Example 3. Let 656714.37512 be given, to find the square Root.

```
                 656714.375120(810.379 Root.
                 64
                 ---
           161)167
               161
               ---
         16203)61437
                48609
                -----
        162067)1282851
               1134469
               -------
       1620749)14838220
               14586741
               --------
       Remains   251479
```

In this Example there are five Places of Decimals; therefore put a Cypher to it, to make it even, that so there may a Point fall upon the Unit's Place.

To find the Square Root of a Fraction.

If it be a Decimal Fraction, the Work differs nothing from the Examples aforegoing, only you must be mindful to point your given Number right; for (as was before directed) the Number of Places must always be made even, and then begin to point at the Right-hand, as in whole Numbers.

If it be a Vulgar Fraction, it must be reduced to a Decimal, by the first Rule of the second Chapter.

I shall give an Example or two in each Case, and so conclude this Chapter.

Let .125 be a Decimal Fraction given, whose square Root is required; and let it be required to have four Places of Decimals in the Root.

```
   ·  ·  ·  ·
 .12500000(.3535
  9
  ---
65)350
   325
   ----
703)2500
    2109
    -----
7065)39100
     35325
     -----
      3775
```

In this Example there must be five Cyphers annexed, because two Places in the Square make but one in the Root.

Let the square Root of .00715 be required.

```
    ·  ·  ·
 .0071 50( 084
    64
   ----
 164)750
     656
     ---
      94
```

In this a Cypher is added to make the Place even.

Let $\frac{7}{8}$ be a Vulgar Fraction given, whose square Root is required.

```
8)7000(.875          (.87500000(.9345
  64                   81
  --                   --
   60              183)650
   56                  549
   --                  ---
    40            1865)10100
    40                  9325
    --                  ----
    ..           18740)77500
                        74816
                        -----
                         2684
```

Reduce this $\frac{7}{8}$ to a Decimal, it makes .875, to which annex Cyphers, and extract the square Root, as if it was a whole Number. So the Root is .9354.

Let $\frac{3}{960}$ be a Vulgar Fraction, whose square Root is required.

```
96|0)3.000000(.003125      (.00312500(.0559 Root.
     288                      25
     ---                      --
      120                 105)625
       96                     525
      ---                     ---
       240               1109)10000
       192                     9981
       ---                     ----
        480                      19
        480
        ---
        ...
```

In

In extracting the Root of this, because the first Point consists of Cyphers, there must be a Cypher put first in the Quotient.

To prove this Rule, square the Root, and to the Product add the Remainder, as was before directed. To square a Number, is to multiply it by itself; and to cube it, is to multiply the Square of the Number by the Number itself.

CHAP. VIII.

Extraction of the CUBE ROOT.

TO extract the Cube Root, is nothing else but to find such a Number, as being first multiplied into itself, and then into that Product, produceth the given Number; which to perform, observe the following Directions.

1st, You must point your given Number, beginning with the Unit's Place, and make a Point, or Dot, over every third Figure towards the Left hand.

2dly, Seek the greatest Cube Number in the first Point, towards the Left-hand, putting the Root thereof in the Quotient, and the said Cube Number under the first Point, and subtract it therefrom, and to the Remainder bring down the next Point, and call that the Resolvend.

3dly, Triple the Quotient, and place it under the Resolvend; the Unit's Place of this under the Ten's Place of the Resolvend; and call this the Triple Quotient.

4thly, Square the Quotient, and triple the Square, and place it under the triple Quotient; the Units of

this under the Ten's Place of the triple Quotient, and call this the Triple Square.

5*thly*, Add these two together, in the same Order as they stand, and the Sum shall be the Divisor.

6*thly*, Seek how often the Divisor is contained in the Resolvend, rejecting the Unit's Place of the Resolvend (as in the Square Root), and put the Answer in the Quotient.

7*thly*, Cube the Figure last put in the Quotient, and put the Unit's Place thereof under the Unit's Place of the Resolvend.

8*thly*, Multiply the Square of the Figure last put in the Quotient, into the triple Quotient, and place the Product under the last, one Place more to the Left-hand.

9*thly*, Multiply the triple Square by the Figure last put in the Quotient, and place it under the last, one Place more to the Left-hand.

10*thly*, Add the three last Numbers together, in the same Order as they stand, and call that the Subtrahend.

Lastly, Subtract the Subtrahend from the Resolvend, and if there be another Point, bring it down to the Remainder, and call that a new Resolvend, and proceed in all Respects as before.

Example

Example 1. Let 314432 be a Cubic Number, whose Root is required.

314432	(68 Root.
216	
98432	Resolvend.
18	Triple Quotient of 6.
108	Triple Square of the Quotient 6.
1098	Divisor.
512	Cube of 8, the last Figure of the Root.
1152	The Square of 8, by the triple Quotient.
864	The triple Square of the Quotient 6 by 8.
98432	The Subtrahend.
.....	

After you have pointed the given Number, seek what is the greatest Cube Number in 314, the first Point, which, by the former little Table, (*Page* 34), you will find to be 216, which is the nearest that is less than 314, and its Root is 6; which put in the Quotient, and 216 under 314, and subtract it therefrom, and there remains 98; to which bring down the next Point, 432, and annex to 98; so will it make 98432 for the Resolvend. Then triple the Quotient 6, it makes 18, which write down the Unit's Place, 8, under 3, the Ten's Place of the Resolvend. Then square the Quotient 6, and triple the Square, and it makes 108, which write under the triple Quotient, one Place toward the Left-hand; then add those two Numbers together, and they make 1098 for the Divisor. Then seek how often the Divisor is contained in the Resolvend, (rejecting the Unit's Place thereof), that is, how often 1098 in 9843, which is 8 times,

8 times; put 8 in the Quotient, and the Cube thereof below the Divisor, the Unit's Place under the Unit's Place of the Resolvend. Then square the 8 last put in the Quotient, and multiply 64, the Square thereof, by the triple Quotient, 18; the Product is 1152; set this under the Cube of 8, the Units of this under the Tens of that. Then multiply the triple Square of the Quotient by 8, the Figure last put in the Quotient, the Product is 864; set this down under the last Product, a Place more to the Left hand. Then draw a Line under those three, and add them together, and the Sum is 98432, which is called the Subtrahend; which being subtracted from the Resolvend, the Remainder is nothing; which shews the Number to be a true cubic Number, whose Root is 68; that is, if 68 be cubed, it will make 314432.

For if 68 be multiplied by 68, the Product will be 4624; and this Product, multiplied again by 68, the last Product is 314432, which shews the Work to be right.

	68
	68
	544
The Work	408
	4624
	68
	36992
	27744
The Proof	314432

Example 2. Let the Cube Root of 5735339 be required.

After you have pointed the given Number, seek what is the greatest Cube Number in 5, the first Point, which (by the little Table, *Page* 34) you will find to be 1; which place under 5, and 1, the Root thereof, in

in the Quotient; and subtract 1 from 5, and there remains 4; to which bring down the next Point, it makes 4735 for the Resolvend. Then triple the 1, and it makes 3; and the Square of 1 is 1, and the Triple thereof is 3; which set one under another, in their Order, and added, makes 33 for the Divisor. Seek how often the Divisor in the Resolvend, and proceed as in the last Example.

```
·  ·  ·
5735339(179 Root
1
----
4735
----
   3  The Triple of the Quotient 1, the first Figure.
  3   The triple Square of the Quotient 1.
----
  33  The Divisor.
----
 343  The Cube of 7, the second Figure of the Root.
147   The Square of 7, multipl. in the triple Quot. 3.
21    The triple Square of the Quot. multiplied by 7.
----
3913  The Subtrahend.
----
 822339 The new Resolvend.
----
     51 The Triple of the Quot. 17, the two first Fig.
   867  The triple Square of the Quotient 17.
----
   8721 Divisor.
----
    729 The Cube of 9, the last Figure of the Root.
  4131  The Squ. of 9, multipl. by the triple Quot. 51.
 7803   The triple Square of the Quotient 867 by 9.
----
 822339 The Subtrahend.
----
```

In

In this Example, 33, the first Divisor, seems to be contained more than seven times in 4795, the Resolvend; but if you work with 9, or 8, you will find that the Subtrahend will be greater than the Resolvend.

Some more Examples for Practice.

32461759(319	Root.
27	
5461	Resolvend.
9	The Triple of 3.
27	The triple Square of 3.
279	The Divisor.
1	The Cube of 1, the second Figure.
9	The triple Quotient, by the Square of 1.
27	The triple Square, multiplied by 1, the 2d Fig.
2791	The Subtrahend.
2670759	A new Resolvend.
93	The Triple of 31.
2883	The triple Square of 31.
28923	The Divisor.
729	The Cube of 9, the last Figure.
7533	The Square of 9, by 93 the triple Quotient.
25947	The triple Square 2883 by 9.
2670759	The Subtrahend.

....

8640

84604519(439	Root.
64	
20604	Resolvend.
12	Triple of 4.
48	Triple Square of 4.
492	Divisor.
27	Cube of 3.
108	Square of 3, by the triple Quotient.
144	Triple Square by 3.
15507	Subtrahend.
5097519	Resolvend.
129	Triple of 43.
5547	Triple Square of 43.
55599	Divisor.
729	Cube of 9.
10449	Square of 9 by 129.
49923	Triple Square by 2.
4097519	Subtrahend.

....

259697989(638
216

43697 Resolvend.

18 Triple of 6.
108 Triple Square of 6.

1098 Divisor.

27 Cube of 3, the second Figure.
162 Triple Square of 3 by 18.
324 Triple Square 108 by 3.

34047 Subtrahend.

9650989 Resolvend.

189 Triple of 63.
11907 Triple Square of 63.

119259 Divisor.

512 Cube of 8.
12096 Square of 8 by 189.
95256 Triple Square 11907 by 8.

9647072 Subtrahend.

3917 Remainder.

```
25917056(295.9
 8
-----
17917 Resolvend.
-----
    6   Triple of 2.
   12   Triple Square of 2.
-----
  126   Divisor.
-----
  729 Cube of 9, the 2d Figure.
 486  Square of 9 by 6.
108   Triple Square by 9.
-----
16389 Subtrahend.
-----
   1528056 Resolvend.
        87 Triple of 29.
      2523 Triple Square of 29.
-----
     25317 Divisor.
-----
       125 Cube of 5, the 3d Figure.
      2175 Square of 5 by 87.
    12615  Triple Square by 5.
-----
   1283375  Subtrahend.
     244681000 Resolvend.
-----
           885  Triple of 295.
        261075  Triple Square of 295.
-----
       2611635  Divisor.
-----
           729 Cube of 9, the last Figure.
         71685 Square of 9 by 885.
     2349675   Triple Square by 9.
     235685079 Subtrahend.
       8995921 Remainder.
```

In this Example I annex 3 Cyphers to the Remainder, which makes the 3d Resolvend; by which means I bring one Place of Decimals. And so you may proceed to more decimal Places at Pleasure, by annexing three Cyphers to the next Remainder, and carrying on the Work as before.

. . . .
2206981012 5(2805
8

14069 Resolvend.

6 Triple of 2.
12 Triple Square of 2.

126 Divisor.

512 Cube of 8.
384 Square of 8 by 6.
96 Triple Square by 8.

13952 Subtrahend.
117810125 New Resolvend.

84 Triple of 28.
2352 Triple Square of 28.

23604 Divisor.

840 Triple of 280.
235200 Triple Square of 280.

2352840 New Divisor.

125 Cube of 5.
21000 Square of 5 by 840.
1176000 Triple Square by 5.

117810125 Subtrahend.

. . . .

In this Example 13952, being subtracted from the Resolvend 14069, the Remainder is 117; to which bring down 810, the 3d Point, and it makes 117810, for a new Resolvend; and the next Divisor is 23604, which you cannot have in the said Resolvend (the Unit's Place being rejected); so you must put 0 in the Quotient, and seek a new Divisor (after you have brought down your last Point to the Resolvend); which new Divisor is 2352840; which you will find to be contained 5 times. So proceed to finish the rest of the Work.

93759·575070(45·42	
64	
29759	Resolvend.
12	Triple of 4, the first Figure.
48	Triple Square of 4.
492	Divisor.
125	Cube of 5, the 2d Figure.
300	Square of 5 by 12, the triple Quotient.
240	Triple Square by 5.
27125	Subtrahend.
2634575	Resolvend.
135	Triple of 45.
6075	Triple Square of 45.
60885	Divisor.
64	Cube of 4.
2160	Square of 4 by 135.
24300	Triple Square by 4.
2451664	Subtrahend.
182911070	Resolvend.
1362	Triple of 45.4.
618348	Triple Square of 45.4
6184842	Divisor.
8	Cube of 2.
5448	Square of 2 by 1362.
236696	Triple Square of 2 by 2.
123724088	Subtrahend.
59186982	Remainder.

In extracting the Cube Root of a mixed Number, always observe to make the decimal Part consist of either three, six, nine, &c. Places; that is, always to consist of even Points, as in the last Example, where the decimal Places were five; to which I annexed a Cypher to make up six, and so I proceed to point it; and by that Means I have a Point fall upon the Unit's Place of whole Numbers, which you must always observe.

To extract the Cube Root out of a Fraction.

This is the same to do as in whole Numbers, observe but the foregoing Directions for the true pointing thereof; for, as was before directed, the Decimal must always consist of three, six, nine, &c. Places; and if it be not so, it must be made so, by annexing Cyphers, as is above said.

If the Cube Root of a Vulgar Fraction be required, you must first reduce it to a Decimal, and then extract the Root thereof.

Examples of each follow.

Example.

Example 1. Let the Cube Root of .401719179 be required.

.401719179(.737	Root.
343	
58719	Resolvend.
21	Triple of 7.
147	Triple Square of 7.
1491	Divisor.
27	Cube of 3.
189	Square of 3 by 21.
441	Triple Square by 3.
46017	Subtrahend.
12702179	Resolvend.
219	Triple of 73.
15987	Triple Square of 73.
160089	Divisor.
343	Cube of 7.
10731	Square of 7 by 219.
111909	Triple Square by 7.
11298553	Subtrahend.
1406236	Remainder.

Example 2. Let the Cube Root of .0001416 be required.

```
.000141600(.052 Root.
   125
 -------
   16600 Resolvend.
 -------
      15  Triple of 5.
     75   Triple Square of 5.
    ----
     765  Divisor.
    ----
       8  Cube of 2.
     60   Square of 2 by 15.
   150    Triple Square by 2.
 -------
   15608  Subtrahend.
 -------
     992  Remainder.
```

Example 3. Let $\frac{5}{276}$ be a Vulgar Fraction, whose Cube Root is required.

By the first Rule of Chapter II. reduce the Vulgar Fraction to a Decimal.

```
276)5.000000000(.018115942
     ---------
     2240
       320
         440
        1640
          2600
           1160
              560
             ----
                8
```

.01811

.018115942(.262 Root.
8

10115 Resolvend.

6 Triple of 2.
12 Triple Square of 2.

126 Divisor.

216 Cube of 6.
216 Square of 6 by the Triple of 2.
72 Triple Square by 6.

9576 Subtrahend.

539942 Resolvend.

78 Triple of 26.
2028 Triple Square of 26.

20358 Divisor.

8 Cube of 2.
312 Square of 2 by 78.
4056 Triple Square 2028 by 2.

408728 Subtrahend.

131214 Remainder.

You may prove the Truth of the Work, by cubing the Root found, as was shewed in the first Example; and if any thing remains, add it to the said Cube, and the Sum will be the given Number, if the Work is rightly performed.

I will

I will ſhew the Proof of the fifth Example (*Page* 50), the given Number being 259697989, whoſe Root is 638, it being a ſurd Number, there remains 3917.

	638
	638
	5104
	1914
	3828
The Square	407044
	638
	3256352
	1221132
	2442264
The Cube	259694072
The Remainder add	3917
Proof equal to the given Numb.	259697989

CHAP. IX.

Multiplication of Feet, Inches, and Parts.

IN the multiplying of Feet, Inches, *&c.* I ſhall endeavour to lay down ſuch eaſy and familiar Rules, as may eaſily be underſtood by the meaneſt Capacity.

Example

Example 1. Let 7 Feet 9 Inches be multiplied by 3 Feet 6 Inches.

F.	I.	
7	9	
3	6	
23	3	*Pts.*
3	10	6
27	1	6

First, Multiply 9 Inches by 3, saying, 3 times 9 is 27 Inches, which make 2 Feet 3 Inches; set down 3 under Inches, and carry 2 to the Feet, saying, 3 times 7 is 21, and 2 that I carry make 23; set down 23 under the Feet.

Then begin with 6 Inches, saying, 6 times 9 is 54 Parts, which is 4 Inches and 6 Parts; set down 6 Parts, and carry 4, saying, 6 times 7 is 42, and 4 that I carry is 46 Inches, which is 3 Feet 10 Inches; which set down, and add all up together, and the Product is 27 Feet 1 Inch 6 Parts.

Example 2. Let 75 Feet 7 Inches be multiplied by 9 Feet 8 Inches.

F.	I.	
75	7	
9	8	
680	3	
50	4	8
730	7	8

First, Multiply by 9 Feet, saying, 9 times 7 is 63, which is 5 Feet 3 Inches; set down 3, and carry 5, saying, 9 times 5 is 45, and 5 I carry is 50; set down 0, and carry 5, saying, 9 times 7 is 63, and 5

is 68; ſet down 68, and proceed to multiply by 8 Inches, ſaying, 8 times 7 is 56; the Twelves in 56 are four times, and 8 remains; ſet 8 a Place to the Right hand, and carry 4: Then multiply 75 by 8, and the Product is 600, and 4 that I carry is 604, which divided by 12, the Quotient in 50 Feet, and 4 remains; ſet down 50 Feet 4 Inches, and add all up together, and you will find the Product 730 Feet 7 Inches 8 Parts.

I will repeat the laſt Example again, and ſhew another Way to work it, which, I think, is better, and more expeditious, when there are more Figures than one in the Feet; thus,

F.	I.	
75	7	
9	8	
680	3	
25	2	4
25	2	4
730	7	8

Multiply by 9 Feet, firſt, as above directed; then, inſtead of multiplying by 8 Inches, let the Inches be parted into ſuch aliquot or even Parts of a Foot, as you find to be contained in that Figure; if you take ſuch Parts of the Multiplicand, and add them to the former Product, the Sum will give the Anſwer: Thus, 8 Inches may be parted into 4, and 4, becauſe 4 is the third Part of 12. So, if you take the third Part of 75 Feet 7 Inches, and ſet it down twice, and add all together, the Sum will be 730 Feet 7 Inches 8 Parts, the ſame as before; thus, ſay how often 3 in 7, which is twice; ſet down 2; then, becauſe twice 3 is 6, ſay, 6 out of 7, and there remains 1, for which you muſt add 10 to the 5, and it makes 15; then the Threes in 15 are 5 times; ſet down 5; and, becauſe 3 times 5 is 15, there is 0 remains. Then go to the

7 Inches, saying, the Threes in 7 are twice; set down 2 in the Inches; and because twice 3 is but 6, take 6 out of 7, and there remains 1 Inch, which is 12 Parts; then the Threes in 12 are 4 times, and 0 remains. So the third Part of 75 Feet 7 Inches, is 25 Feet 2 Inches 4 Parts; which set down again, and add all together, the Sum is 730 Feet 7 Inches 8 Parts; the same as before.

Example 3. Let 97 Feet 8 Inches be multiplied by 8 Feet 9 Inches.

F.	I.
97	8
8	9
781	4
48	10
24	5
854	7

Begin, first, to multiply by 8 Feet, saying, 8 times 8 is 64 Inches, that is, 5 Feet 4 Inches; set down 4 Inches, and carry 5, saying, 8 times 7 is 56, and 5 I carry is 61; set down 1, and carry 6, saying, 8 times 9 is 72, and 6 I carry is 78, which set down: Then, instead of multiplying by 9 Inches, take the aliquot Parts of 12 which 9 makes, which is 6 and 3; 6 Inches being half 12, and 3 the fourth Part; therefore take the half of 97 Feet 8 Inches, which is 48 Feet 10 Inches; and because 3 is half 6, you may take the half of 48 Feet 10 Inches, which is 24 Feet 5 Inches; add all up together, and the Sum is 854 Feet 7 Inches. See the Work, as above.

Example 4. Let 75 Feet 9 Inches be multiplied by 17 Feet 7 Inches.

F.	I.	
75	9	
17	7	
525		
75		
25	3	P.
18	11	3
8	6	
4	3	
1331	11	3

In this Example, because there are more than 12 Feet in the Multiplier, therefore I first multiply the 75 by 17 Feet; then, because the aliquot Parts in 7 Inches are 4 and 3, that is, a third and a fourth, I take the third Part of 75 Feet 9 Inches, which is 25 Feet 3 Inches, and the fourth Part thereof is 18 Feet 11 Inches 3 Parts; then the aliquot Parts of 9 Inches are 6 and 3, that is, half and a fourth; therefore I take half 17 Feet, which is 8 Feet 6 Inches, and the fourth Part is 4 Feet 3 Inches (not meddling with the 7 Inches, because that was multiplied into the 9 before); then add all these together, and the Sum is 1331 Feet 11 Inches 3 Parts.

Example 5. Let 87 Feet 5 Inches be multiplied by 35 Feet 8 Inches.

F.	I.	P.
87	5	
35	8	
435		
261		
29	1	8
29	1	8
11	8	0
2	11	0
3117	10	4

Work here as in the last Example. After you have multiplied the Feet, then take the aliquot Parts of 8 Inches, which are two Thirds; therefore take the third Part of 87 Feet 5 Inches, and set it down twice. Thus the third Part of 87 Feet 5 Inches is 29 Feet 1 Inch 8 Parts; set this down twice; then the aliquot Parts of 5 Inches are 4 and 1, that is, a third Part and a 12th Part; therefore take a third Part of 35, which is 11 Feet 8 Inches, and a 12th Part of 35 is 2 Feet 11 Inches; set all these one under another, and add them together, and the Sum is 3117 Feet 10 Inches 4 Parts.

Example 6. Let 259 Feet 2 Inches be multiplied by 48 Feet 11 Inches.

F.	I.	P.
259	2	
48	11	
2072		
1036		
129	7	
86	4	8
21	7	2
8	0	0
12677	6	10

First, multiply the Feet; then take the aliquot Parts of 11, which will be 6, 4, and 1, that is, a half, a third, and a twelfth; therefore take the half of 297 Feet 2 Inches, which is 129 Feet 7 Inches, and a third Part is 86 Feet 4 Inches 8 Parts, and the twelfth Part of 259 Feet 2 Inches is 21 Feet 7 Inches 2 Parts; or (because 1 is the fourth Part of 4), you may more readily take the fourth Part of 86 Feet 4 Inches 8 Parts, which is also 21 Feet 7 Inches 2 Parts; then 2 Inches are the sixth of 12, take the sixth of 48 Inches, which will be 8 Inches, which place under the Inches; then add all together, and the Sum is 12677 Feet 6 Inches 10 Parts. See the foregoing Work.

I shall set down only the working of some few Examples in Feet and Inches, and then proceed to multiply Feet, Inches, and Parts, *&c.*

	F.	I.	P.
	179	3	
	38	10	
	1432		
	537		
	89	7	6
	59	9	0
	9	6	0
Product	6960	10	6

	F.	I.	P.
	246	7	
	46	4	
	1476		
	984		
	82	2	4
	15	4	0
	11	6	0
Product	11425	0	4

	F.	I.	P.
	246	7	
	36	9	
	1476		
	738		
	123	3	6
	61	7	9
	12	0	0
	9	0	0
	9061	11	3

	F.	I.	P.
	257	9	
	39	11	
	2313		
	771		
	128	10	6
	85	11	0
	21	5	9
	19	6	0
	9	9	0
Product	10288	6	3

Example

Example 11. Let 7 Feet 5 Inches 9 Parts be multiplied by 3 Feet 5 Inches 3 Parts.

F.	I.	P.		
7	5	9		
3	5	3		
22	5	3	S.	
3	1	4	9	T.
	1	10	5	3
25	8	6	2	3

In this Example, I first begin with 3 Feet, and thereby multiply 7 Feet 5 Inches 9 Parts: First, I say, 3 times 9 is 27 Parts, that is, 2 Inches and 3 Parts; set down 3 under the Parts, and carry 2, saying, 3 times 5 is 15, and 2 I carry is 17, that is, 1 Foot 5 Inches; set down 5 Inches, and carry 1, and say, 3 times 7 is 21, and 1 I carry is 22; set down 22 Feet: Then begin with 5 Inches, saying 5 times 9 is 45, which is 45 Seconds, which make 3 Parts and 9 Seconds; set down 9 Seconds a Place towards the Right-hand, and carry 3 Parts, saying, 5 times 5 is 25, and 3 I carry is 28, which is 2 Inches and 4 Parts; set down 4 Parts, and carry 2, saying, 5 times 7 is 35, and 2 I carry is 37, which is 3 Feet 1 Inch; set down 3 Feet 1 Inch, and begin to multiply by 3 Parts, saying, 3 times 9 is 27 Thirds, that is, 2 Seconds and 3 Thirds; set down 3 Thirds, and carry 2, saying, 3 times 5 is 15, and 2 I carry is 17, that is, 1 Part and 5 Seconds; set down 5 Seconds, and carry 1, saying, 3 times 7 is 21, and 1 I carry is 22, which is 1 Inch and 10 Parts, which set down, and add all up, and the Product is 25 Feet 8 Inches 6 Parts 2 Seconds 3 Thirds.

Note, That in multiplying Feet, Inches, and Parts, *&c.* if Feet be multiplied by Feet, the Product is Feet; and Feet multiplied by Inches, the Product is Inches:

and the twelfth Part is Feet; and Parts multiplied by Feet, the Product is Parts, and the twelfth Part thereof is Inches; Parts multiplied by Inches, the Product is Seconds, and the twelfth Part thereof is Parts; and Parts multiplied by Parts, the Product is Thirds, and the twelfth Part thereof is Seconds. So that if you begin to multiply Parts by Feet in the first Row, and Parts by Inches in the second Row, and Parts by Parts in the third Row, the first Figure in every Row will stand a Place more towards the Right-hand, as you may see in the last Example.

Example 12. Let 37 Feet 7 Inches 5 Parts be multiplied by 4 Feet 8 Inches 6 Parts.

F.	I.	P.		
37	7	5		
4	8	6		
150	5	8	S.	
12	6	5	8	
12	6	5	8	T.
1	6	9	8	6
177	1	5	0	6

First, I multiply by 4 Feet, saying, 4 times 5 is 20, which is 1 Inch 8 Parts; set down 8, and carry 1, saying, 4 times 7 is 28, and 1 I carry is 29, which is 2 Feet 5 Inches; set down 5 Inches, and carry 2, saying, 4 times 7 is 28, and 2 I carry is 30; set down 0, and carry 3, and say, 4 times 3 is 12, and 3 is 15; set down 15. Then I begin with 8 Inches; but, because the Feet in the Multiplicand are more than 12, it will be the best Way to work for the aliquot Parts of 8; so here I work for 4 Inches, and set that down twice, 4 being the third Part of 12; therefore take the third Part of 37 Feet 7 Inches 5 Parts, which is twelve Feet six Inches five Parts eight Seconds; set this down twice: Then begin with 6 Parts; but, instead of multiplying, take half 37 Feet 7 Inches

5 Parts.

5 Parts (because 6 is half 12), and set it a Place more to the Right-hand: Thus, the half of 37 Feet is 18, which I must count 18 Inches, because the Multiplier is 6 Parts; so the half of 37 Feet 7 Inches 5 Parts, is one Foot six Inches nine Parts eight Seconds six Thirds; which set down, and add all up together, and the Sum is 177 Feet 1 Inch 5 Parts 0 Seconds 6 Thirds.

Example 13. Let 311 Feet 4 Inches 7 Parts be multiplied by 36 Feet 7 Inches 5 Parts.

F.	I.	P.	S.	T.
311	4	7		
36	7	5		
1866				
933				
103	9	6	4	
77	10	1	9	
8	7	9	6	4
2	1	11	4	7
12	0	0	0	0
1	0	0	0	0
	9	0	0	0
11402	2	4	11	11

In this Example, because the Feet both in the Multiplier and Multiplicand are compound Numbers, I first multiply the Feet one by the other; then take the aliquot Parts of 7 Inches, which are 4 Inches and 3, that is, a third and a fourth Part; so take the third Part of 311 Feet 4 Inches 7 Parts, which is 103 Feet 9 Inches 6 Parts 4 Seconds, and the fourth Part is 77 Feet 10 Inches 1 Part 9 Seconds; set these down one under another, the Feet under the other Feet; then the aliquot Parts of 5 Parts are 4 and 1, that is, a third and twelfth Part; so the third Part of 311 Feet 4 Inches 7 Parts is 103 Feet 9 Inches 6 Parts 4 Seconds; but, because the Multiplier is Parts, it must be set a Place

to

to the Right-hand, that is, the 103 must be Inches, which is 8 Feet 7 Inches; therefore I set down 8 Feet 7 Inches 9 Parts 6 Seconds 4 Thirds. Then, because 1 Inch is a fourth Part of 4 Inches, therefore I take a fourth Part of 8 Feet 7 Inches 9 Parts 6 Seconds 4 Thirds, which is 2 Feet 1 Inch 11 Parts 4 Seconds 7 Thirds, which is the same as if I had taken a twelfth Part of 311 Feet 4 Inches 7 Parts. Then for 4 Inches in the Multiplicand, instead of multiplying 36 Feet by it, take a third Part, because 4 Inches is the third Part of 12; so the third Part of 36 is 12 Feet, and the aliquot Parts of 7 Parts are 4 and 3, that is, a third and a fourth; so the third Part of 36 is 12, which now is 12 Inches, that is, 1 Foot, and the fourth Part is 9 Inches; add all these together, and the Sum will be 11402 Feet 2 Inches 4 Parts 11 Seconds 11 Thirds.

Example 14. Let 8 Feet 4 Inches 3 Parts 5 Seconds 6 Thirds, be multiplied by 3 Feet 3 Inches 7 Parts 8 Seconds 2 Thirds.

	F.	I.	P.	S.	T.				
	8	4	3	5	6				
	3	3	7	8	2				
	25	0	10	4	6				
	2	1	0	10	4	6			
		1	10	6	0	2	6		
			5	6	0	3	8	0	
				1	4	8	6	11	0
Product	27	7	3	5	1	8	8	11	0

In this last Example there is no Difficulty, if you do but observe the former Directions, and set every Row a Place more to the Right-hand.

I shall only set down the working of some few Examples more, and so conclude this Chapter.

F.	I.	P.	S.	T.
321	7	3		
9	3	6		
2894	5	3		
80	4	9	9	
13	4	9	7	6
2988	2	10	4	6

F.	I.	P.	S.
42	7	8	
7	3	6	
298	5	1	
10	7	11	
1	9	3	10
310	10	10	10

F.	I.	P.	S.	T.
124	7	9		
14	6	2		
496				
124				
62	3	10	6	
1	8	9	3	6
7	0	0	0	0
1	2	0	0	0
	7	0	0	0
	2	6	0	0
1809	0	1	9	6

F.	I.	P.	S.	T.
259	10	8		
18	5	4		
2072				
259				
86	7	6	8	
21	7	10	8	
7	2	7	6	8
9	0	0	0	0
6	0	0	0	0
1	0	0	0	0
4793	6	0	10	8

F.	I.	P.		
267	7	10		
25	9	7		
1335				
534				
133	9	11	S.	
66	10	11	6	
11	1	9	11	T.
1	10	3	7	10
12	6	0	0	0
2	1	0	0	0
1	0	6	0	0
	8	1	0	0
6905	0	7	0	10

F.	I.	P.		
317	9	7		
37	5	9		
2219				
951			S.	
105	11	2	4	
26	5	9	7	T.
13	2	10	9	6
6	7	5	4	9
18	6	0	0	0
9	3	0	0	0
1	6	6	0	0
	3	1	0	0
11910	9	11	1	3

THE

THE
Complete Measurer, &c.

PART II.

CHAP. I.

Menſuration of SUPERFICIES.

Superficial Figures are all ſuch as have only Length and Breadth, not having any commenſurable Thickneſs.

§ I. *Of a* SQUARE.

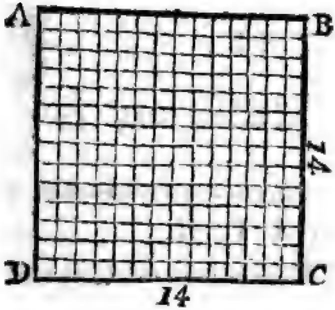
A SQUARE is a Geometrical Figure, having four equal Sides, and as many right (or ſquare) Angles. To find the ſuperficial Content thereof, this is

The RULE.

Multiply the Side into itſelf, and the Product is the Content.

Let

Let ABCD be a Geometrical Square given, each Side being 14 Feet, Yards, Poles, or other Meafure; multiply 14 by itfelf, and the Product is 169, which is the fuperficial Content.



$$\begin{array}{r} 14 \\ 14 \\ \hline 56 \\ 14 \\ \hline 196 \end{array}\ \text{Product.}$$

By Scale and Compaffes.

Extend the Compaffes from 1, in the Line of Numbers, to 14; the fame Extent will reach from the fame Point, turned forward to 196.

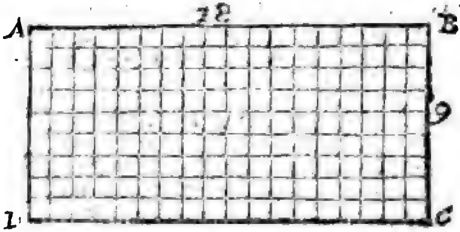
Demonftration. Let each Side of the given Square be divided into 14 equal Parts, and Lines drawn from one another, croffing each other within the Square; fo fhall the whole great Square be divided into 196 little Squares, as you may fee in the Figure above, equal to the Number of Square Feet, Yards, Poles, or other Meafures, by which the Side was meafured.

§ II. *Of a* PARALLELOGRAM, *or* *Long Square.*

A Parallelogram is a Figure having four Sides, and as many Right Angles, the opposite Sides thereof being equal and parallel. To find the superficial Content thereof, this is

The RULE.

Multiply the Length by the Breadth, and the Product is the superficial Content.



Length — 18
Breadth — 9

Product — 162

Let ABCD be a long Square, the Length thereof 18 Feet, and the Breadth 9 Feet; which multiplied together, the Product is 162, the superficial Content thereof.

By Scale and Compasses.

Extend the Compasses in the Line of Numbers from 1 to 9, the same Extent will reach from 18 down to 162, the square Feet.

Demonſtration. If the Sides AB and CD be each divided into 18 equal Parts, repreſenting 18 Feet; and the Lines AD and BC each divided into 9 equal Parts, and Lines drawn from Point to Point, croſſing each other within the Figure; thoſe Lines will make thereby ſo many little Squares as there are ſquare Feet, *viz.* 162.

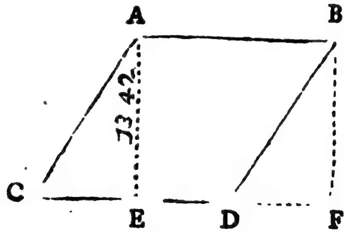
§ III. *Of a* RHOMBUS.

A Rhombus is a Figure repreſenting a Quarry of Glaſs, having four equal Sides, the Oppoſites thereof being equal, two Angles being obtuſe, and two acute. To find the ſuperficial Content thereof, this is

The RULE.

Multiply one of the Sides by a Perpendicular let fall from one of the obtuſe Angles to the oppoſite Side, and the Product is the Content.

Perpend.	13.42
The Side	15.5
	6710
	6710
	1342
Product	208.010



Let ABCD be a Rhombus given, whoſe Sides are each 15.5 Feet, and the Perpendicular EA is 13.42, which multiplied together, the Product is 208.010; which is the ſuperficial Content of the Rhombus, that is, 208 Feet and one hundredth Part of a Foot.

By

By Scale and Compasses.

Extend the Compasses from 1 to 13 42, that Extent will reach from 15.5, the same Way to 208 Feet the Content.

Demonstration. Let CD be extended out to F, making DF equal to CE, and draw the Line BF; so shall the Triangle DBF be equal to the Triangle ACE: For DF and CE are equal, and BF is equal to AE, because AB and CF are parallel. Therefore the Parallelogram ABEF is equal to the Rhombus ABCD.

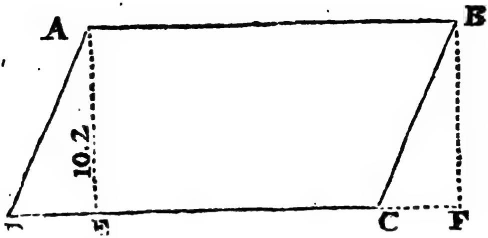
§ IV. *Of a* RHOMBOIDES.

A Rhomboides is a Figure having four Sides, the opposite whereof are equal and parallel; and also four Angles, the opposite whereof are equal. To find the superficial Content thereof, this is

The RULE.

Multiply one of the longest Sides thereof by the Perpendicular let fall from one of the obtuse Angles to one of the longest Sides, and the Product is the Content.

$$
\begin{array}{r}
19.5 \\
10.2 \\
\hline
390 \\
195 \\
\hline
198.90
\end{array}
$$



Let ABCD be a Rhomboides given, whoſe longeſt Sides, AB or CD, is 19.5 Feet, and the Perpendicular AE is 10.2; which multiplied together, the Product is 198.9, that is, 198 ſuperficial Feet and 9 tenth Parts, the Content.

Demonſtration. If DC be extended to F, making CF equal to DE, and a Line drawn from B to F; ſo will the Triangle CBF be equal to the Triangle ADE, and the Parallelogram AEFB be equal to the Rhomboides ABCD; which was to be proved.

§ V. *Of a* TRIANGLE.

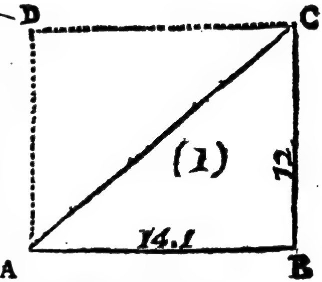
A Triangle is a Figure having three Sides and three Angles. Triangles are either right-angled or oblique-angled. Right angled Triangles are ſuch as have one Right Angle. Oblique-angled Triangles are ſuch as have their Angles either acute or obtuſe. An obtuſe Angle is greater than a Right Angle, that is, it is more than 90 Degrees; and an acute Angle is leſs than a Right Angle. To find the ſuperficial Content thereof, this is

The

The RULE.

Let the Triangle be of what Kind foever, multiply the Bafe by half the Perpendicular, or half the Bafe by the whole Perpendicular; or, multiply the whole Bafe by the whole Perpendicular; and take half the Product; any of thefe three Ways will give the Content.

Let ABC be a Right-angled Triangle, whofe Bafe is 14.1 Feet, and the Perpendicular 12 Feet. Multiply 14.1 by 6, half the Perpendicular, and the Product is 84.6 Feet, the Content. Or, multiply 14.1 by 12, the Product is 169.2; the half thereof is 84.6, the fame as before.



14.1 Bafe.
6 Half Perpendicular.

84.6 Product.

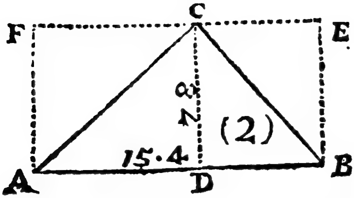
14.1 Bafe.
12 Perpendicular.

169.2 Product.

84.6 Half.

By Scale and Compaffes.

Extend the Compaffes from 2 to 14.1, that Extent will reach the fame Way from 12 to 84.6 Feet, the Content.



15 4 Bafe.
3.9 Half Perp.

1386
462

60.06 Product.

15.4 Bafe.
7.8 Perpend.

1232
1078

120.12

60.06 Half.

7.7 Half Bafe.
7.8 Perpendicular.

616
539

60.06 Product.

Let ABC (*Fig.* 2.) be an oblique-angled Triangle given, whofe Bafe is 15.4, and the Perpendicular 7.8; if 15.4 be multiplied by 3.9 (half the Perpendicular), the Product will be 60.06 for the Area, or fuperficial Content: Or, if the Perpendicular 7.8 be multiplied into half the Bafe 7.7, the Product will be 60.06 as before: Or, if 15.4, the Bafe, be multiplied by the whole Perpendicular 7.8, the Product will be 120.12, which is the double Area; the Half thereof is 60.06 Feet, as before. See the Work.

By Scale and Compaffes.

Extend the Compaffes from 2 to 15.4, that Extent will reach from 7.8 to 60 Feet, the Content.

Demonftration. If AD (*Fig.* 1.) be drawn parallel to BC, and DC parallel to AB; the Triangle ADC fhall be equal to the given Triangle ABC. Hence the Parallelogram ABCD is double to the given Triangle; therefore half the Area of the Parallelogram is

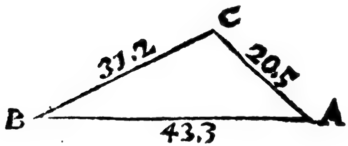
is the Area of the Triangle. In *Fig.* 2. the Parallelogram ABEF is alſo double to the Triangle ABC; for the Triangle ACF is equal to the Triangle ACD, and the Triangle BCE is equal to the Triangle BCD; therefore the Area of the Parallelogram is double to the Area of the given Triangle: Which was to be proved.

To find the Area of any plain Triangle by having the three Sides given, without the Help of a Perpendicular.

The RULE.

Add the three Sides together, and take half that Sum: Then ſubtract each Side ſeverally from that half Sum. Which done, multiply that half Sum and the three Differences continually, and out of the laſt Product extract the Square Root; which Square Root ſhall be the Area of the Triangle ſought.

Example. Let ABC be a Triangle, whoſe three Sides are as followeth; *viz.* AB 43.3, AC 20.5, and BC 31.2, the Area is required.



Sides	43.3	4.2	Differences.
	31.2	16.3	
	20.5	27.0	
Sum	95.0		
Half	47.5		

Area

Area 296.31 — 47.5 The half Sum.
27 Difference.

3325
950

1282.5 Product.
16.3 Difference.

38475
76950
12825

20904.75 Product.
4.2 Difference.

4180950
8361900

87799.9500(296.31
4

49)477
441

586)3699
3516

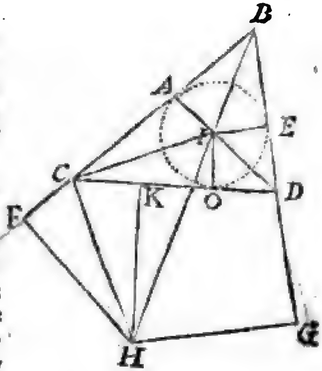
5923)18395
17769

59261)62600
59261

3339 Remains.

Demon-

Demonftration. In the Triangle BCD, I fay, If from the half Sum of the Sides, you fubtract each particular Side, and multiply the half Sum and the three Differences together continually, the Square Root of the Product fhall be the Area of the Triangle.



Firft, by the Lines BI, CI, and DI, bifect the three Angles, which Lines will all meet in the Point I; by which Lines the given Triangle is divided into three new Triangles, CBI, DCI, and BDI; the Perpendiculars of which new Triangles are the Lines AI, EI, and OI, being all equal to one another, becaufe the Point I is the Center of the infcribed Circle (by *Euclid*, *Lib* IV. *Prop.* 4): Wherefore to the Side BC join CF equal to DE, or DO; fo fhall BF be equal to half the Sum of the Sides; *viz.* $=\frac{1}{2}BC+\frac{1}{2}BD+\frac{1}{2}CD$.

And $BA=BF-CD$; for $CA=CO$ and $OD=CF$; therefore $CD=AF$; and $AC=BF-BD$, for $BE=BA$, and $ED=CF$; therefore $BD=BA+CF$, and $CF=BF-BC$.

Then make $CK=CF$, and draw the Perpendiculars FH, GH, and KH, and extend BI to H; becaufe the Angle $FCK+FHK$ are equal to two Right Angles (for the Angles F and K are Right Angles) equal alfo to $FCK+ACO$ by (*Euclid* I. 13), and the Angles $ACO+AIO$ are equal to two Right Angles; therefore the Quadrangles FCKH and AIOC are alike; and the Triangles CFH and AIC are alfo fimilar. And the Triangles BAI and BFH are likewife fimilar.

From

From this Explanation, I say, the Square of the Area of the given Triangle will be BF $q \times$ IA $q =$ BF $\times$ BA $\times$ CA $\times$ CF. In Words:

The Square of BF (the half Sum of the Sides) multiplied into the Square of IA ($=$IF$=$IO) will be equal to the said half Sum multiplied into all the three Differences.

For IA : BA : : FH : BF; and IA : CF : : AC : FH; because the Triangles are similar. By *Euclid, Lib.* VI. *Prop.* 4.

Wherefore multiplying the Extremes and Means in both, it will be IA $q \times$ BF $\times$ FH $=$ BA $\times$ CA $\times$ CF $\times$ FH; but FH being on both Sides of the Equation, it may be rejected; and then multiply each Part by BF, it will be BF $q \times$ IA $q =$ BF $\times$ BA $\times$ CA $\times$ CF. Which was to be demonstrated.

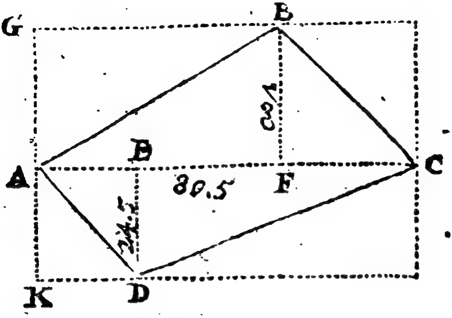
§ VI. *Of a* TRAPEZIUM.

A Trapezium is a Figure having 4 unequal Sides, and oblique Angles. To find the Area or superficial Content thereof, this is

The RULE.

Add the two Perpendiculars together, and take half the Sum, and multiply that half Sum by the Diagonal, or multiply the whole Sum by half the Diagonal, the Product is the Area. Or you may find the Areas of the two Triangles, ABC and ACD (by Section V.), and add those two Areas together, the Sum shall be the Area of the Trapezium.

BF$=$30.1



BF=	30.1
DE=	24.5
Sum	54.6
Half	27.3
AC=	80.5
	1365
	1284
Area	2197.65

Let ABCD be a Trapezium given, the Diagonal whereof is 80.5, and the Perpendicular BF 30.1, and the Perpendicular DE 24.5; these two added together, the Sum is 54.6, the Half thereof is 27.3, which multiplied by the Diagonal 80.5, the Product is 2197.65, which is the Area of the Trapezium; or if 40.25, half the Diagonal, be multiplied by 54.6, the whole Sum of the Perpendiculars, the Product is 2197.65, the same as before.

By

By Scale and Compaffes.

Extend the Compaffes from 2 to 54.6; that Extent will reach from 80.5 to 2197.65, the Area.

Demonftration. This Figure ABCD is compofed of two Angles; the Triangle ABC is half the Parallelogram AGHC: Alfo the Triangle ACD is equal to half the Parallelogram ACIK, as was proved, Sect. V. Wherefore the Trapezium ABCD is equal to half the Parallelogram GHIK. To find the Area HI $=$ BF $+$ DE; therefore $\frac{1}{2}$ HI $\times$ AC ($=$KI$=$GH) $=$Area of the Trapezium, which was to be proved.

§ VII. *Of* Irregular Figures.

IRregular Figures are all fuch as have more Sides than four, and the Sides and Angles unequal. All fuch Figures may be divided into as many Triangles as there are Sides, wanting two. To find the Area of fuch Figures, they muft be divided into Trapeziums and Triangles, by Lines drawn from one Angle to another; and fo find the Areas of the Trapeziums and Triangles feverally, and then add all the Areas together; fo will you have the Area of the whole Figure.

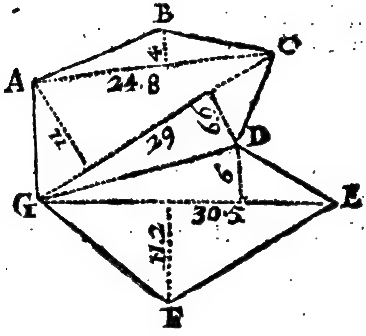
Let ABCDEFG be an irregular Figure given to be meafured; firft, draw the Lines AC and GD, and thereby divide the given Figure into two Trapeziums, ACGD and GDEF, and the Triangle ABC; of all which I find the Area feverally.

Firft, I multiply the Bafe AC by half the Perpendicular, and the Product is 49.6, the Area of the Triangle ABC.

Then

Then for the Trapezium ACDG, the two Perpendiculars, 11 and 6.6, added together, make 17.6; the half thereof is 8.8, multiplied by 29, the Diagonal; the Product is 255.2, the Area of that Trapezium.

And for the Trapezium GDEF, the two Perpendiculars, 11.2 and 6, added together, make 17.2; the Half thereof is 8.6; which multiplied by 30.5, the Diagonal, the Product is 262.3, the Area thereof. All these Areas added together, make 567.1, and so much is the Area of the whole irregular Figure. See the Work.



24.8	Base AC.	11	Perpendicular.
2	Half Perpendicular.	6.6	
49.6	Area of ABC.	17.6	Sum.
		8.8	Half.
		29	Diagonal CG.
		792	
		176	
		255.2	Area of ACGD.

11.2 } Perpendiculars.		30.5	
6		8.6	
17.2 Sum.		1830	
		2440	
8.6 Half Sum.			
		262.30	Area of GDEF.
		255.2	Area of ACGD.
		49.6	Area of ABC.
		567.1	Sum of the Areas.

This Figure being compofed of Triangles and Trapeziums, and thofe Figures being fufficiently demonftrated in the Vth and VIth Sections aforegoing, it will be needlefs to mention any thing of the Demonftration thereof in this Place.

§ VIII. *Of* Regular Polygons.

REgular Polygons are all fuch Figures as have more than four Sides, all the Sides and Angles thereof being equal. Polygons are denominated from the Number of their Sides and Angles.

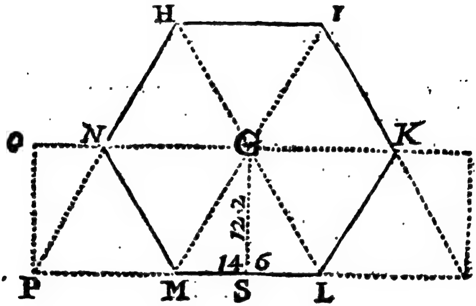
If the Figure confifts of		Equal Sides and Angles, it is called a Regular	
	5		Pentagon.
	6		Hexagon.
	7		Heptagon.
	8		Octagon.
	9		Enneagon.
	10		Decagon.
	11		Endecagon.
	12		Dodecagon.

To

To find the Area or superficial Content of any regular Polygon, this is

The RULE.

Multiply the whole Perimeter, or Sum of the Sides, by half the Perpendicular let fall from the Center to the Middle of one of the Sides; or multiply the half Perimeter by the whole Perpendicular, and the Product is the Area.



14.6
3
——
43 8 Half Sum of the Sides.
——
12.64 The Perpendicular.
43.8 Half Sum.
——
10112
3792
5056
——
553.632

14.6
6
——
87.6 Sum of the Sides.
6.32 Half Perpend.
——
1752
2628
5256
——
553.632 Area.

Let HIKLMN be a Regular Hexagon, each Side thereof being 14.6, the Sum of all the Sides is 87.6, the half Sum thereof is 43.8, which multiplied by the Perpendicular GS 12.64, the Product is 553.632: Or, if 87.6, the whole Sum of the Sides, be multiplied by half the Perpendicular 6.32, the Product is 553.632, the fame as before, which is the Area of the given Hexagon.

By Scale and Compaffes.

Extend the Compaffes from 1 to 12.2, that Extent will reach from 43.8, the fame Way to 553.632: Or, extend from 2 to 12.2, that Extent will reach from 87.6 to 553.632.

Demonftration. Every regular Polygon is equal to the Parallelogram, or long Square, whofe Length is equal to half the Sum of the Sides, and Breadth equal to the Perpendicular of the Polygon, as appears by the foregoing Figure; for the Hexagon HIKLMN is made up of fix equilateral Triangles: And the Parallelogram OPQR is alfo compofed of fix equilateral Triangles, that is, five whole ones, and two Halves; therefore the Parallelogram is equal to the Hexagon.

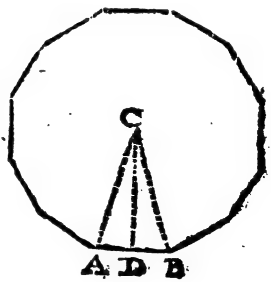
A TABLE *for the more ready finding the Area of a Polygon.*

Number of Sides.	Names.	Multipliers.
3	Trigon	.433013
4	Tetragon	1.000000
5	Pentagon	1.720477
6	Hexagon	2.598076
7	Heptagon	3.633959
8	Octagon	4.828427
9	Enneagon	6.181827
10	Decagon	7.694209
11	Endecagon	8.514250
12	Dodecagon	9.330125

Multiply the Square of the Side by the Tabular Number, and the Product is the Area of the Polygon.

How to find these Tabular Numbers.

These Numbers are found by Trigonometry, thus: Find the Angle at the Center of the Polygon by dividing 360 Degrees by the Number of Sides of the Polygon.



Example. Suppose each Side of the Dodecagon annexed be 1, and the Area be required.

Divide

Divide 360 by 12 (the Number of Sides), and the Quotient is 30 Degrees for the Angle ACB; the Half thereof is 15, the Angle DCB, whose Complement to 90 Degrees is 75 Degrees, the Angle CBD: Then say:

As s, DCB 15 Degrees is	Co-ar.	0.587004
to .5 the Half-side DB. Log.		1.698970
so is s, CBD 73 Degrees,		9.984944
to the Perpendicular CD 1.866025		0.270918

Then 1.866025 multiplied by .5 (the Half side) the Product is 9.330125 the Area of the Dodecagon required.

§. IX. *Of a* CIRCLE.

A Circle is a plain Figure, contained under one Line, which is called a Circumference, unto which all Lines drawn from a Point in the Middle of the Figure, called the Center, and falling upon the Circumference thereof, are all equal the one to the other. The Circle contains more Space than any plain Figure of equal Compass.

Problem 1. Having the Diameter and Circumference, to find the Area.

The RULE.

Every Circle is equal to a Parallelogram, whose Length is equal to half the Circumference, and the Breadth equal to half the Diameter; therefore multi-

ply

ply half the Circumference by half the Diameter, and the Product is the Area of the Circle.

35.5 Half Circumf.
11.3 Half Diameter.

1065
355
355

401.15 Area.

Thus, if the Diameter of a Circle (that is, the Line drawn croſs the Circle through the Center) be 22.6; and if the Circumference be 71, the Half of 71 is 35.5, and the Half of 22.6 is 11.3; which multiplied together, the Product is 401.15, which is the Area of the Circle.

Demonſtration. Every Circle may be conceived to be a Polygon of an infinite Number of Sides, and the Semidiameter muſt be equal to the Perpendicular of ſuch a Polygon, and the Circumference of the Circle equal to the Periphery of the Polygon; therefore half the Circumference, multiplied by half the Diameter, gives the Area as aforeſaid.

Or (with *F. Ignat. Gaſton Pardies*) "Every Circle "is equal to a Rectangle Triangle, one of whoſe "Legs is the Radius, and the other a Right Line "equal to the Circumference of the Circle: For "ſuch a Triangle will be greater than any Polygon "inſcribed, and leſs than any Polygon circumſcribed, "by the 24th, 25th, 26th, and 27th Articles of the "fourth Book of his Elements of Geometry; and "therefore muſt be equal to the Circle.

"For

For (fays he) fhould it be greater than the Circle, " be the Excefs as little as it will, a Polygon may be " circumfcribed, whofe Difference, from the Circle, " fhall be yet lefs than the Difference between that " Circle and the Rectangle Triangle; and that that " Polygon will be lefs than the Triangle, is abfurd; " and if it be faid, that this rectangled Triangle is " lefs than the Circle, an infcribed Polygon may be " made, which fhall be greater than that Triangle; " which is impoffible.

" This cannot but be admitted as a Principle, That " if two determinate Quantities, A and B, are fuch " that if every imaginable Quantity, which is greater " or lefs than A, is alfo greater or lefs than B, thefe " two Quantities A and B muft be equal.

" And this Principle being granted, which is in a " manner felf-evident, it may directly be proved, that " the Triangle (before-mentioned) is equal to the " Circle; becaufe every imaginable infcribed Figure, " which is lefs than the Circle, is alfo lefs than the " Triangle; and every circumfcribed Figure, greater " than the Circle, is alfo greater than the Triangle."

Problem 2. Having the Diameter of a Circle, to find the Circumference.

As 7 to 22, fo is the Diameter to the Circumference.

Or, as 113 to 355, fo is the Diameter to the Circumference.

Or, as 1 to 3.141593, fo is the Diameter to the Circumference.

Let the Diameter (as in the former Circle) be 22.6, this multiplied by 22, and the Product is 497.2; which, divided by 7, gives 71.028 for the Circumference.

ference. Or (by the fecond Proportion) if 22.6 be multiplied by 355, the Product will be 8023; this divided by 11.3, the Quotient is 71, the Circumference. Or (by the third Proportion) if 22.6 be multiplied into 3.141593, the Product is 71.0000018 the Circumference; which two laft Proportions are the moft exact.

```
      22.6                      355
        22                     22.6
     -----                    -----
       452                     2130
      452                      710
     -----                    710
7)497.2(71.028              -------
                          113)8023.01(71
                               791
                              -----
                               113
                               113
                              -----

   3.141593
       22.6
   --------
   18849558
   6283186
  6283186
  ---------
  71.0000018
```

By Scale and Compaffes.

Extend the Compaffes from 7 to 22, or from 113 to 355, or from 1 to 3.14159; that Extent will reach from 22.6 to 71.

The Proportion of the Diameter of a Circle to the Circumference was never yet exactly found, notwithftanding many eminent learned Men have laboured very far therein; among which the excellent *Van Culen* hath hitherto outdone all, in his having calculated the faid Proportion to 36 Places of Decimals, which are engraven upon his Tomb-ftone in St. *Peter's* Church in *Leyden*; which Numbers are thefe:

Diameter.

Diameter.
1.00000.00000.00000.00000.00000.00000.00000.

Circumference.
3.14159.26535.89793.23846.26433.83279.50288.

Of which large Number, theſe ſix Places, 3.14159, anſwering to the Diameter 1.00000, may be ſufficient; of the three Proportions, as 7 to 22, 113 to 355, and 1 to 3.14159, I ſhall leave my Reader to uſe which of them he pleaſes, but ſhall commend the laſt two as moſt exact, tho' the firſt be moſt in Uſe: But in the following Work I ſhall uſe ſometimes one of them, and ſometimes another; but for the moſt Part that of *Van Culen*, as being moſt exact.

Problem 3. Having the Circumference of a Circle, to find the Diameter.

As 1 is to .318309, ſo is the Circumference to the [illegible]

[illegible] as 355 to 113, ſo is the Circumference to the [illegible]

[illegible] 22 to 7, ſo is the Circumference to the [illegible]

Let the Circumference be 71 (as in the former Circle), if .318309 be multiplied by 71 (as by the firſt Proportion), the Product will be 22.599939 for the Diameter. Or, by the ſecond Proportion, 113 multiplied by 71, the Product is 8023; which divided by 355, the Quotient will be 22.6 the Diameter. Or, by the third Proportion, 71 multiplied by 7, the Product is 497; this divided by 22, the Quotient is 22.5909, the Diameter.

.318309

.318309	113	71
71	71	7
318309	113	22)497(22.59
2228163	791	44
22.599939	355)8023(22.6	57
	710	44
	923	130
	710	110
	2130	200
	2130	198
	...	2

Thus, by both the firſt Proportions, the Diameter is 22.6, but by the laſt it falls ſomething ſhort.

By Scale and Compaſſes.

Extend the Compaſſes from 3.14159 to 1, that Extent will reach from 71 to 22.6, which is the Diameter ſought.

Or, you may extend from 1 to .318309.

Or from 22 to 7.

Or from 355 to 113; the ſame will reach from 71 to 22.6, as before.

Note, That if the Circumference be 1, the Diameter will be .318309.

Problem 4. Having the Diameter of a Circle, to find the Area.

All Circles are in Proportion one to another, as are the Squares of their Diameters (by *Euclid* 12.2). Now, the Area of a Circle, whoſe Diameter is 1, will be .785398, according to *Van Culen*'s Proportion before;

before-mentioned; but for Practice .7854 will be sufficient: Therefore,

As 1 (the Square of the Diameter 1) is to .7854, so is 510.76 (the Square of 22.6, the Diameter of the given Circle) to 401.15 (the Area of the given Circle): But,

According to *Metius*'s Proportion,

As 452 : 355 :: 510.76 : 401.15, the same as before.

But, if you use *Archimedes*'s Proportion, say,

As 14 : 11 :: 510.76 : 401.31; which Area is greater than by the two former Proportions; though in small Circles this is near enough the Truth. See the Working of all these.

```
     22.6  Diameter of the former Circle.
     22.6
     ----
     1356
     452
    452
   -----
   510.76 the Square of the said Diameter.

As 1 : .7854 :: 51076
         .7854
       -------
        204304
       255380
      408608
     357532
   ----------
   401.150904 the Area.
```

By

By Scale and Compasses.

The Extent from 1 to 22.6, being twice turned over from .7854, will fall at the last upon 401.15, the Area.

```
 113          As 452 : 355 :: 510.76
   4                             355
 ---                          ------
 452                          255380
                             255380
                            153228
                          ----------
                      452)181319.80(401.15
                          1808
                          ----
                             519
                             452
                             ---
                              678
                              452
                              ---
                             2260
                             2260
                             ----
                             ....
```

As 14 : 11 :: 510.76

```
          510.76
              11
          ------
      14)5618.36(401.31
         56
         --
          18
          14
          --
           43
           42
           --
            16
            14
            --
             2
```

Problem 5. Having the Circumference of a Circle to find the Area.

Becauſe the Diameters of Circles are proportional to their Circumferences; that is, as the Diameter of one Circle is to its Circumference; ſo is the Diameter of another Circle to its Circumference: Therefore the Areas of Circles are to one another, as the Squares of the Circumferences. And if the Circumference of a Circle be 1, the Area of that Circle will be .07958; then the Square of 1 is 1, and the Square of 71 (the Circumference of the former Circle) is 5041. Therefore it will be,

```
       Sq. Cir.   Area.   Sq. Circumf.
       As  1  : .07958  ::  5041
                 5041
               ---------
                 7958
22              31832
 4             397900
--             ---------
88             401.16278
```

Or

Or thus:

As 88 : 7 : : 5041
7

88)35287(400.98 Area.
352

870
792

780
704

76

355
4

1420

Or, As 1420 : 113 : : 5041 : 401.15 Area.

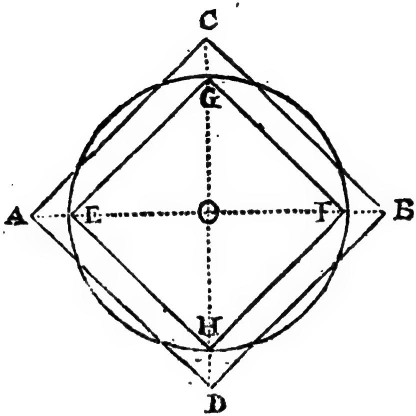
Problem 6. By having the Diameter, to find the Side of a Square that is equal in Area to that Circle.

If the Diameter of a Circle be 1, the Side of a Square equal thereunto will be .8862. Therefore,

As 1 : .8862 : : 22.6 (the Diameter)
22.6

53172
17724
17724

To 20.02812 the Side of the Square AC.



Let the Diameter of the Circle EF or GH, be 22.6 (as before), to find the Side of the Square AC, AD, &c. If .8862 be multiplied by 22.6, the Product is 20.02812, which is the Side of a Square, equal in Area to the Circle given; for if 20.02812 be multiplied Square-wiſe, that is, by itſelf, it will produce 401.1255907344, which is nearly equal to the Area found in the laſt Problem.

You may find the Side of the Square equal, by extracting the Square Root out of the Area of the given Circle.

```
         . . .
        401.15(20.0287295 Side of a Square.
        4
       ------
  4002)01.1500
          8004
          ------
   40048)349600
    .... 320384
          ------
           29216
           28034
          ------
            1182
             801
           -----
             381
             360
           -----
              21
              20
              --
               1
```

N. B. By this Method of extracting the Square Root of the Area, you may find the Side of a Square equal to any plain Figure, regular or irregular.

Problem 7. By having the Circumference, to find the Side of the Square equal.

If the Circumference of a Circle be 1, the Side of the Square equal will be .2821. Therefore,

```
As 1 : .2821 : : 71 (the Circumference)
           71
        ------
          2821
        19747
        ------
       20.0291 the Side of the Square.
```

Problem 8. Having the Diameter, to find the Side of a Square, which may be inscribed in that Circle.

If the Diameter of a Circle be 1, the Side of the Square inscribed will be .7071. Therefore,

As 1 : .7071 : : 22.6
22.6

42426
14142
14142

To 15.98046 the Side EG inscribed.

Or, if you square the Semidiameter and double that Square, the Square Root of the doubled Square will be the Side of the Square inscribed. For (by *Euclid*, 1.47), the Square of the Hypothenuse EG is equal to the Sum of the other two Legs, EO and OG.

11.3 Semidiameter.
11.3

339
113
113

127.69 the Square of EO, which double, because EO=OG.
2

255.38(15.98 Root, which is the Side of the Sq.
1

25)155
125

309)3038
2781

3188)25700
25504

196

Problem

Problem 9. Having the Circumference, to find the Side of a Square which may be infcribed.

If the Circumference be 1, the Side of the Square infcribed will be .2251. Therefore,

$$\begin{array}{r} \text{As } 1 : .2251 :: 71 \\ 71 \\ \hline 2251 \\ 15757 \\ \hline 15.9821 \end{array}$$ the Side of the Sq. EG.

Becaufe that in each of the four laft Problems, *viz.* the 6th, 7th, 8th, and 9th, there is a Proportion laid down, it will be eafy to work them with Scale and Compaffes; for if you extend the Compaffes from the firft to the fecond, that Extent will reach from the third to the fourth: As in the laft Problem, where the Proportion is as 1 to .2251, fo is 71 to the Side of the Square 15.9821. Here extend the Compaffes from 1 to .2251; that Extent will reach from 71 to 15.98; and fo of the reft. But the fifth muft be wrought like the fourth, thus; extend the Compaffes from 1 to 71; that Extent, turned over the fame Way from .07958, will fall, at laft, upon 401.15.

Problem 10. Having the Area, to find the Diameter.

If the Area of a Circle be 1, the Square of the Diameter thereof is 1.2732. Therefore,

Area.

```
Area. Sq. Diam.   Area.
As 1 : 1.2732 :: 401.15
          401.15
          ------
           63660
          12732
         12732
        509280
        --------
        . . . . . .
        510.744180(22.599 the Diameter.
        4
     ------
     42)110
         84
       ------
     445)2674
         2225
         ----
     4509)44941
          40581
         -------
    45189)436080
          406701
         -------
           29379
```

By Scale and Compasses.

Extend the Compasses from 1 to 1.2732; that Extent will reach from 401.15 to 510.74, &c. Then divide the Space between 1 and 510.74 into two equal Parts, and you'll find the middle Point at 22.6. Or you may divide the Space upon the Line of Numbers, between 401.15 and .7854, into two equal Parts, and one of those Parts will reach from 1 to 22.6, the Diameter sought.

Problem

Problem 11. Having the Area, to find the Circumference.

If the Area of a Circle be 1, the Square of the Circumference will be 12.56637. Therefore,

```
    Ar. Sq. Circumf.    Area.
    As 1 : 12.56637 : : 401.15
               401.15
              --------
              6283185
             1256637
            1256637
          50265480
          ----------
          . . . . . .
          5040.99932550(70.9990 Root.
          49
          ----
   1409)14099
         12681
         -----
   14189)141893
          127701
          ------
   141989)1419225
           1277901
           -------
   1419989)14132450
            12779901
            --------
             1352549
```

By Scale and Compasses.

Divide the Space between 401.15 and .07958, upon the Line, into two equal Parts; one of those Parts will reach from 1 to 71, the Circumference sought.

Problem

Problem 12. Having the Area, to find the Side of a Square inscribed.

If the Area of a Circle be 1, the Area of a Square inscribed within that Circle will be .6366. Therefore,

```
As 1 : 401.15 : : .6366
         .6366
        ------
        240690
       240690
      120345
     240690
   -----------
   255.372090(1.598 Root, which is the Side of
   1                      [the Square sought.
   ----
 25)155
    125
   -----
 309)3037
     2781
    -----
 3188)25620
      25504
      -----
       11690
```

The same Reason may be given for the last Proportion, that was given before for the Proportion of Circles to the Squares of their Diameters and Circumferences; for not only the Squares of the Diameters and Circumferences are in Proportion to the Circles they belong to, but also all Figures inscribed or circumscribed, have the Squares of their like Sides proportioned to the Squares they are inscribed in, or circumscribed about; and also to the Figures themselves: The Square of any Side of one Figure is to the Area of that

that Figure, as the Square of the like Side of another similar Figure is to the Area thereof; as you may find proved at large in *Euclid, Sturmius, Mathesis, Enucleata,* and other Authors; but will be too large to insert in this Place.

By Scale and Compasses.

Extend the Compasses from 1 to 401.15, that Extent will reach from .6366 to 255.37; the half Space between that and 1 is at 15.98, the Side of the Square.

Problem 13. Having the Side of a Square, to find the Diameter of the circumscribing Circle.

If the Side of a Square be 1, the Diameter of a Circle that will circumscribe that Square, will be 1.4142. Therefore,

$$\begin{array}{l} \text{As } 1 : 1.4142 :: 15.98 \\ \qquad\qquad 15.98 \\ \hline \qquad\quad 113136 \\ \qquad\ \ 127278 \\ \qquad\ \ 70710 \\ \qquad 14142 \\ \hline 22.598916 \text{ the Diameter sought.} \end{array}$$

By Scale and Compasses.

Extend the Compasses from 1 to 1.4142, and that Extent will reach from 15.98 to 22.6, the Diameter sought.

Problem

Problem 14. Having the Side of a Square, to find the Diameter of a Circle equal.

If the Side of a Square be 1, the Diameter of a Circle equal thereunto will be 1.128. Therefore,

Side Diam. Side of a Square.

As 1 : 1.128 : : 20.0291

1.128

1602328
400582
200291
200291

22.5928248 Diameter.

By Scale and Compasses.

Extend the Compasses from 1 to 1.128; that Extent will reach from 20.0291 (the Side of the Square given) to 22.6, the Diameter of the Circle sought.

Problem 15. Having the Side of a Square, to find the Circumference of a circumscribing Figure.

If the Side of a Square be 1, the Circumference of a Circle that will encompass that Square will be 4.443. Therefore,

Side Sq. Circum. Side Sq.

As 1 : 4.443 : : 15.98

15.98

35544
39987
22215
4443

70.99914 the Circumference.

By Scale and Compasses.

Extend the Compasses from 1 to 4.443, that Extent will reach from 15.98 to 71, the Circumference.

Problem

Problem 16. Having the Side of a Square, to find the Circumference of a Circle that will be equal thereunto.

If the Side of a Square be 1, the Circumference of a Circle that will be equal thereunto, shall be 3.545. Then,

As 1 : 3.545 : : 20.0291
3.545

1001455
801164
1001455
600873

71.0031595 the Circumference.

By Scale and Compasses.

Extend the Compasses from 1 to 3.545, that Extent will reach from 20.0291 to 71, the Circumference sought.

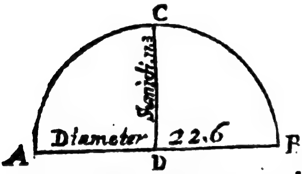
In several of the foregoing Problems, where the Diameter and Circumference are required, the Answers are not exactly the same as the Diameter and Circumference of the given Circle, but are sometimes too much, and sometimes too little, as in the two last Problems, where the Answers in each should be 71, the one being too much, and the other too little. The Reason of this is, the small Defect that happens to be in the Decimal Fractions, they being sometimes too great, and sometimes too little; yet the Defect is so small, that it is needless to calculate them to more Exactness.

§ X. *Of a* SEMICIRCLE.

TO find the Area of the Semicircle, this is

The RULE.

Multiply the fourth Part of the Circumference of the whole Circle (that is, half the Arch Line) by the Semidiameter, the Product is the Area.



Let ABC be a Semicircle, whofe Diameter 22.6, and the half Circumference, or Arch Line, ACB, is 35.5, the Half thereof is 17.75, which multiply by the Semidiameter 11.3, and the Product is 200.575, the Area of the Semicircle.

```
 17.75  the half Arch Line.
  11.3  the Semidiameter.
 ------
  5325
 1775
1775
 ------
200.575 the Area of the Semicircle.
```

By Scale and Compaffes.

Extend the Compaffes from 1 to 11.3; that Extent will reach from 17.75 to 200.575, the Area.

If only the Diameter of the Semicircle be given, you may fay, by the *Rule of Three,*

As 1 is to .3927, fo is the Square of the Diameter to the Area.

By

By Scale and Compasses.

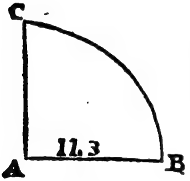
Extend the Compasses from 1 to the Diameter 22.6; that Extent turned twice from .3927, will reach, at the last, to 200.575.

§ XI. *Of a* QUADRANT.

TO find the Area of a Quadrant, or fourth Part of a Circle, this is

The RULE.

Multiply half the Arch Line of the Quadrant (that is, the eighth Part of the Circumference of the whole Circle), by the Semidiameter, and the Product is the Area of the Quadrant.



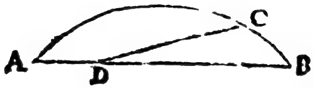
Let ABC be a Quadrant, or fourth Part of a Circle, whose Radius, or Semidiameter, is 11.3, and the half Arch Line 8.875; these multiplied together, the Product is 100.2875 for the Area.

These are the Rules and Ways commonly given for finding the Area of a Semicircle and Quadrant; but, I think, it is as good a Way, to find the Area of the whole Circle, and then take half that Area for the Semicircle, and a fourth Part for the Quadrant.

Before I proceed to shew how to find the Area of the Sector, and Segment of a Circle, I shall shew how to find the Length of the Arch Line, both *Geometrically* and *Arithmetically*.

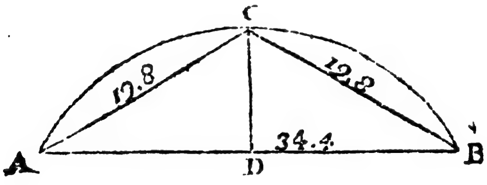
To find the Length of the Arch Line *Geometrically.*

Divide the Chord Line AB into four equal Parts, and set one of these Parts from B to C, and draw a Line from C to three of those Parts at D, so shall CD be equal to half the Arch Line ACB.



To find the Length of the Arch Line *Arithmetically.*

Multiply the Chord of half the Segment AC or CB by 8, and from the Product subtract the Chord of the whole Segment AB, and divide the Remainder by 3; the Quotient is the Arch Line ACB sought.



19.8	AC
8	
158.4	
34.4	AB
3)124	
Arch Line 41.333	

Another

Another Way.

From the double Chord of half the Segment's Arch, fubtract the Chord of the Segment, one third Part of the Difference added to the double Chord of half the Segment's Arch, the Sum is the Arch Line of the whole Segment.

Thus, if AC 19.8 be doubled, it makes 39.6; from which, if you fubtract 34.4, the Remainder is 5.2, which, divided by 3, the Quotient is 1.733; this added to 39.6 (the double Chord of the half Segment), the Sum is 41.333. So if the Arch Line ACB was ftretched out ftrait, it would then contain 41.333 fuch Parts as the Chord AB contains 34.4 of the like Parts.

Thefe two Rules may very eafily be proved out of the Table of natural Sines; thus,

Suppofe (in the former Figure) the Arch ACB to contain 120 Degrees; the natural Sine of half, *viz.* of 60 Degrees, is 86602; which, being doubled, is 173204, which is the Chord of the whole 120 Degrees, that is, AB. Then, to find the Chord of the half Arch, *viz.* AC 60 Degrees, the half of it 30 Degrees, the natural Sine thereof is 50000; which, doubled, makes 100000 for the Chord AC; then, according to the firft Rule, multiply 100000 by 8, the Product is 800000; from which fubtract 173204 (the Chord AB), and the Remainder is 626796; which divide by 3, the Quotient is 208932, which is the Length of the Arch Line ACB, according to the firft Rule. Now let us examine how near this comes to the true Quantity of the Arch propofed. If the Radius or Semidiameter of a Circle be 100000 (as in the Table of Sines), then the Circumference will be 628318; and becaufe 120 Degrees is the third Part of the Circle, take the third Part of 628318, which is 209439, which is the true Quantity of the Arch ACB in fuch Parts as

the Semidiameter contains 100000, and differs from that before found 507, which is a thing inconsiderable in *Practical Mensuration.* The latter of the foregoing Rules agrees exactly with the former, and therefore the Difference will be the same as above; either of the Rules gives the Quantity of the Arch Line too little, and the greater the Arch, the greater the Error. If you know the Degrees that are contained in the Segment's Arch, and would have the Arch Line very exactly, you may reason thus by the *Rule of Three:*

As the Circles's Periphery in Degrees, is to its Periphery in equal Parts; so is the Arch in Degrees and decimal Parts, to the same Arch in equal Parts.

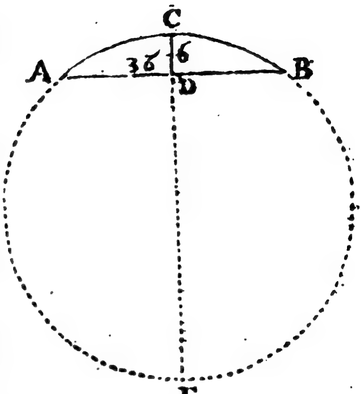
Suppose the Circumference of a Circle be 71, and suppose the Arch to contain 52 Degrees 15 Minutes (the Decimal of 15 Minutes is .25); then say,

```
    Deg. Parts.   Deg.
As 360 : 71 : : 52.25
                  71
                ----
                5225
               36575
               -----
        36|0)370|9.75(10.305 fere.
               36
               --
               109
               108
               ---
                175
```

So the 52 Degrees 15 Minutes will contain 10.305 of such Parts as the Circumference contains 71.

Thus have I shewed several Ways of finding the Measure of the Curve Line of any Part of a Circle very near the Truth. The next Thing I shall shew, is,

How to find the Diameter of a Circle by having the Chord and verſed Sine of the Segment Arithmetically.



Becauſe the Chord AB cuts the Diameter EC at right Angles, therefore the Semichord AD, or DB, is a mean proportional Line between the Parts of the Diameter CD and DE (by *Euc.*6.13.); therefore, if you ſquare the Semichord AD, or DB, and divide the Square by the verſed Sine CD, the Quotient will be the Part of the Diameter wanting; to which add the given verſed Sine CD, and the Sum is the Diameter ſought.

Example. Let ACB be a Segment given, whoſe Chord AB is 36, and the verſed Sine CD 6; half 36 is 18; which, ſquared, makes 324; this divided by 6, the Quotient is 54: To which add 6, the Sum is 60, the Diameter of the Circle CE.

18 half

18 half the Chord.
18

144
18

6)324 the Square of AD.

54 the Part wanting DE.
6 the verfed Sine CD add.

60 the Diameter CE.

§ XII. *Of the Sector of a* CIRCLE.

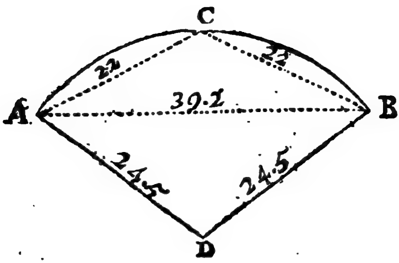
A Sector of a Circle is comprehended under two Radii, or Semidiameters, which are fuppofed not to make one Right Line, and a Part of the Circumference: Whence a Sector may be either lefs or greater than a Semicircle. To find the Area or fuperficial Content thereof, this is

The RULE.

Multiply half the Arch Line by the Semidiameter; and the Product is the Area.

Let ADBC be the Sector of a Circle given, whofe Semidiameter AD or BD is 24.5, and the Arch Line ACB (by the firft Rule, *Pag.* 112.) I find to be 45.6; the half thereof, 22.8, being multiplied by 24.5 (the Semidiameter) the Product is 558.6; which is the Area of the Sector ACBD.

22

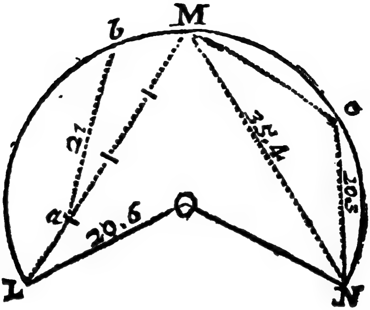


$$
\begin{array}{rl}
22 & \\
8 & \\
\hline
176 & \\
39.2 & \text{Subtrah} \\
\hline
3)136.8 & \\
\hline
45.6 & \text{Arch Line.} \\
\hline
22.8 & \text{half.} \\
24.5 & \text{Semidiam.} \\
\hline
1140 & \\
912 & \\
456 & \\
\hline
558.60 & \text{the Area.}
\end{array}
$$

Again: Let LMNO be a Sector greater than a Semicircle, whofe Semidiameter LO or NO is 20.6, and the Line *b a* equal to a fourth Part of the Arch Line L *b* MN 21, the Double whereof is 42, equal to the Arch Line L *b* M or M *c* N; or by the arithmetical Rule, *Pag.* 112. the faid Arch is found to be 42.333; which, multiplied by 20.6, the Semidiameter, makes 872.0598 for the Area of the Sector LMNO.

See the following Work.

20.3



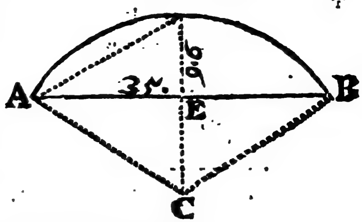
20.3	Chord N *e*.	42.333	
8		20.6	
162.4		253998	
35.4	Chord MN.	84666	
3)12.70		872.0598	Area.
42.33	Arch Line.		

§ XIII. *Of the Segment of a* CIRCLE.

A Segment of a Circle is a Part terminated by a Right Line lefs than the Diameter, called a Chord, and by a Part of the Circumference.

To find the Area of the Segment of a Circle, you muft, firft, find the Center of the whole Circle, and draw the two Semidiameters, thereby completing the Sector, as in the following Figure. Then (by the laft Section), find the Area of the whole Sector CADBC, and then (by Sect. 5.) find the Area of the Triangle ABC, and fubtract the Area of the Triangle out of the Area of the Sector, the Remainder is the Area of the Segment.

Other-



Otherwiſe you may, without deſcribing the Figure, find the Semidiameter of the Circle by the arithmetical Rule (*Pag.* 113.) and by the arithmetical Rule (*Pag.* 112.) to find the Arch Line; then multiply half the Arch Line by the Semidiameter; ſo have you the Area of the Sector: Then ſubtract the verſed Sine from the Semidiameter, the Remainder is the Perpendicular of the Triangle; and multiply the half Chord by the Perpendicular, the Product is the Area of the Triangle: Then ſubtract the Area of the Triangle from the Area of the Sector, and the Remainder is the Area of the Segment. See the Work.

2)35=AB

17.5
17.5

875
1225
175

9.6)306.25(31.9
9.6 add.

182
865 41.5 the Diameter of the Circle.

1 20.75 the Semidiameter.
9.6 DE Subtrahend.

11.15 remains the Perpendicular EC.

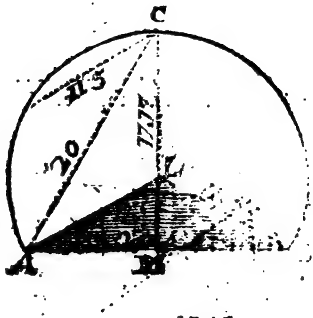
```
   11.15 the Perpendicular BC.
    17.5 half the Chord AE or EB.
  -------
    5575
   7805
  1115
  -------
 195.125 the Area of the Triangle.

  306.25 the Square of AE.
   92.16 the Square of DE the versed Sine.
  -------
  398.41 Sum.
```

The Square Root thereof is 19 96 the Chord AD.

```
                      8
                 -------
                 159.68
             Sub. 35     the Chord AB.
                 -------
               3)124.6
                 -------
                2)41.56 the Arch Line.
                 -------
                  20.78 half.
                  20.75 Semidiameter.
                 -------
                  10390
                 14546
                4156
                 -------
From      431.1850 Area of the Sect.
Subtract  195.125  Area of the Tri.
          --------
Remains   236.060  Area of the Seg.
```

Again:

Again: Let MACBM be a Segment greater than a Semicircle; obſerve the former Rules in all reſpects, as in the laſt Example; only, inſtead of ſubtracting the Area of the Triangle out of the Area of the Sector, here you muſt add it thereunto, as may plainly appear by the following Figure.



11.5
8

92.0
20

3)72

24 Half Arch Line.

11.64 Semidiam.
24

4656
2328

279.36 Area of the Sector LACBL.

17.1
11 64

5.53 LM.

10.25 half the Baſe MA.
5.53 the Perpendicular LM.

3075
5125
5125

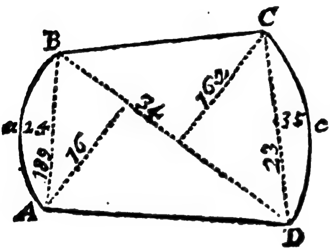
56.6825 the Area of the Triangle ALM.
279.36 the Area of the Sector add.

336.0425 the Area of the Segment ſought.

§ XIV. *Of Compound* FIGURES.

MIXED or compound Figures are such as are composed of rectilineal and curvilineal Figures together.

To find the Area of such mixed Figures, you must find the Area of the several Figures of which the whole compound Figure is composed, and add all the Areas together, and the Sum will be the Area of the whole compound Figure.



16.2 } add.
16

32.2 Sum.

16.1 half.
34 Diagonal.

644
483

547.4 Area of the Trapezium.

10.236 half the Arch Line A a B.
14.83 Semidiameter of the Arch AB.

30708
81888
40944
10236

151.79988 Area of the Sector.

From

From 14.83 Semidiameter.
Subtract 3.4 Verſed Sine.

11.43 Perpend. of the Triangle.
9.45 half the Chord AB.

5715
4572
10287

108 0135 the Area of the Tria. ſubtracted from
151.7999 the Area of the Sector.

43.7864 the Area of the Segment A a BA.

12.19 half the Arch Line C c D.
20.64 Semidiameter.

4876
7314
24380

251.6016 the Area of the Sector.

From 20.64 the Semidiameter.
Subtract 3.5 Verſed Sine.

Rema. 17.14 Perpendicular of the Triangle.
11.5 half the Chord DC.

8570
1714
1714

Sub. 197.110 Area of the Triangle.
From 251.602 Area of the Sector.

Rem. 54.492 the Area of the Segment C c DC.
43.786 the Area of the Segment A a BA.
547.4 the Area of the Trapezium.

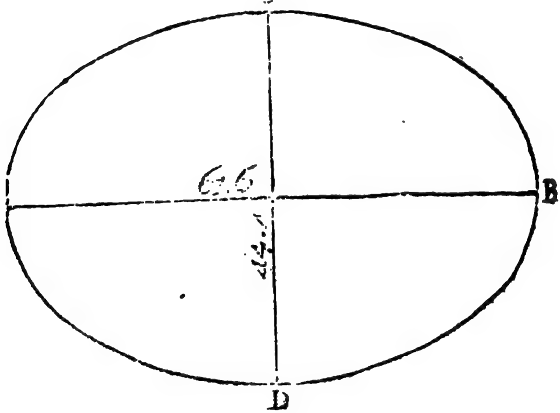
Sum 645.678 the Area of the Whole.

§ XV. *Of an* ELLIPSIS.

AN Ellipsis, or Oval, is a Figure bounded by a regular Curve Line, returning into itself; but of its two Diameters, cutting each other in the Center, one is longer than the other, in which it differs from the Circle. To find the Area thereof, this is

The RULE.

Multiply the traverse Diameter by the Conjugate, and multiply that Product by .7854, this last Product is the Area of the Oval.



61.6

61.6 the traverſe Diameter.
44.4 the conjugate Diameter.

2464
2464
2464

2735.04 the Rectangle.
.7854 the Area of Unity.

1094016
1367520
2188032
1914528

2148 100416 the Area of the Oval.

Demonſtration. If you circumſcribe any Ellipſis with a Circle, and ſuppoſe an infinite Number of Chord Lines drawn therein, all parallel to the conjugate Diameter, as theſe in the following Figure; then it will be,

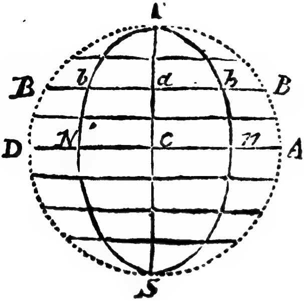
As DA, the Diameter of the Circle, is to N n, the conjugate Diameter of the Ellipſis; ſo is B a B, any Chord in the Circle, to b a b, its reſpective Ordinate in the Ellipſis.

For, according to the Property of the Circle,

it is	1	$aS \times Ta = \square Ba$.
And		by the Property of the Ellipſis,
it is	2	$\square TC : \square NC :: aS \times Ta : \square ba$.
1, 2	3	$\square TC : \square NC :: \square Ba : \square ba$.
3, hence	4	$TC : NC :: Ba : ba$.
Conſq.	5	$TC : 2NC :: 2Ba : 2ba$.
That is	6	$DA : Nn :: Bab : bab$.

But the Sum of an infinite Series of ſuch Chords as B a b, do conſtitute the Area of the Circle. And the Sum of the like Series of their reſpective Ordinates, as b a b, do conſtitute the Area of the Ellipſis:

 There-



Therefore TS : Nn : : Circle's Area : the Ellipſis Area. But TS : Nn : : □ TS : TS×Nn; whence it follows, that,

□ TS : Cirele's Area : : TS × Nn : Ellipſis Area.

Conſequent'y, As 1 is to .7854, ſo is the Rectangle, or Product, of the tranſverſe and conjugate Diameter of any Ellipſis to its Area.

Hence it is eaſy to conceive, that the Square Root of the Product of the tranſverſe and conjugate Diameters will be the Diameter of a Circle equal to the Ellipſis.

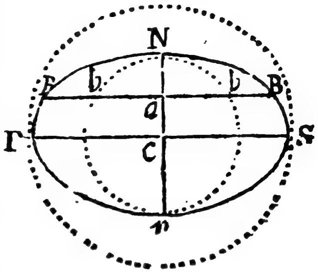
Hence alſo the Segments of an Ellipſis, and its circumſcribing Circle (whoſe Baſes are parallel to the conjugate Diameter, and of the ſame Height), are in Proportion one to another as their Baſes are. That is,

B a B : b a b : : Area Segment BTB : Area Segment b T B.

Or, TS : N n : : Area Segment BTB : Area Segment b T b.

The Area of every Ellipſis is a mean Proportional between the Area of its circumſcribing and inſcribed Circles.

The



The Truth of this may easily be deduced from the last; for 'tis already proved, that □ TS : TS × Nn :: circumscribing Circle's Area : Ellipsis Area.

But □ TS : TS × Nn : : TS × Nn : □ Nn. Therefore Ellipsis Area : inscribed Circle's Area : TS × Nn : □ Nn.

Example. Let TS = 36, and Nn = 18.4. Then □ TS = 1296, and □ Nn = 338.56. Then 1296 × .7854 = 1017 8784 great Circle's Area; And 338.56 × .7854 = 265.905, &c. lesser Circle's Area; And 36 × 18.4 = 662.4 × .7854 = 520.24896, which is the Area of the Ellipsis; then it will be,

1017.878 : 520.24896 : : 520.24896 : 265.905024.

That is, As the great Circle's Area is to the Area of the Ellipsis, so is the Area of the Ellipsis to the Area of the lesser Circle.

From hence it follows, that all Segments of an Ellipsis, and its inscribed Circle (whose Bases are parallel to the transverse Diameter, and have the same Height) are in Proportion one to another as the Area of the Ellipsis and Circle are.

That is, as the Area of the Circle is to the Area of the Ellipsis, so is the Segment b N b : to the Segment BNB;

Or, Nn : TS : : Area Segment b N B : Area Segment BNB.

§ XVI.

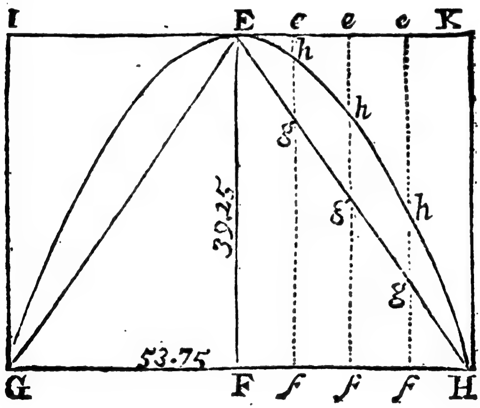
§ XVI. *Of a* PARABOLA.

A Parabola is a curvilineal Figure, made by the Section of a Cone, being cut by a Plane parallel to one of its Sides.

Every Parabola is Two-thirds of its circumſcribing Parallelogram; therefore to find the Area thereof, this is

The RULE.

Multiply the Baſe, or greateſt Ordinate, by the perpendicular Height, and multiply that Product by 2, and divide the laſt Product by 3, the Quotient will be the Area of the Parabola.



53.75 the Ordinate GH.
39 25 the Perpendicular EF.

26875
10750
48375
16125

2109.6875
2

3)4219.3750

1406.4583 the Area.

Demonstration. Let FH, the Semi-ordinate, be divided into four equal Parts, or into 8.16, *&c.* and through the Divisions draw Lines, as e f, e f, *&c.* parallel to the Axis EF. Suppose also EF to be 4.

Then, I say, the Parabolic Sphere Eh HF is to the Parallelogram EKFH as 2 to 3; but to the Triangle EFH as 4 to 3.

For, first, g f, g f, g f, *&c.* are in continual arithmetical Proportion from the Nature of plain Triangles.

Secondly, f e : g e : : g e : h e; but h e is the Axis EF$=$o; and in the first Parallel e f must be equal to $\frac{1}{4}$, in the next e f must be equal to $\frac{4}{4}$, in the third to $\frac{2}{4}$, and so on, in a duplicate arithmetical Progression.

For e f ($=4$) : g e ($=1$) : : g e ($=1$) : e h ($=\frac{1}{4}$). And the second e f ($=4$) : e g ($=2$) : : e g ($=2$) : e h ($=\frac{4}{4}$), *&c.* And thus it will be, if the Lines F f, f f, *&c.* be again bisected, *&c. ad infinitum*, so that all the Indivisibles of the trilinear Space EK H h E will be in a duplicate arithmetical Progression increasing. But the Sum of a Rank of such Terms is subtriple to a Rank of as many equal to the greatest (by Lemma 3); wherefore the whole trilinear Space E K H h E is to the Parallelogram as 1 to 3; and, consequently, the remaining parabolic Space must be to it as 2 to 3: which was to be proved.

5 And

And ſince the Triangle FEH is to the Parallelogram as 1 to 2, it muſt be to the Parabola as $1\frac{1}{2}$ to 2, or as 3 to 4; which was to be proved.

Before I proceed to the Menſuration of ſolid Bodies, I will lay down ſuch Lemmas as will be neceſſary to facilitate the Demonſtration of all ſuch Solids.

LEMMA I.

In any Series of equal Numbers (repreſenting Lines or other Quantities), as 1, 1, 1, 1, *&c.* or 2, 2, 2, 2, *&c.* or 3, 3, 3, 3, *&c.* if one of the Terms be multiplied into the Number of Terms, the Product will be the Sum of all the Terms in the Series.

LEMMA II.

If a Series of Numbers, in arithmetical Progreſſion, begin with a Cypher, and the common Difference be 1, as 0, 1, 2, 3, *&c.* (repreſenting a Series of Lines or Roots beginning with a Point) if the laſt Term be multiplied into the Number of Terms, the Product will be double the Sum of all the Series.

That is, putting $L=$the laſt Term, $N=$the Number of Terms, and $S=$the Sum of all the Series; then will $NL=2S$; conſequently, $\frac{1}{2}NL=S$; *viz.* One half of ſo many times the greateſt Term as there are Numbers of Terms in the Series.

$$\text{Thus}\begin{cases}0+1+2+3+4=10 \text{ the Sum}=\frac{1}{2}NL.\\ 4+4+4+4+4=20=NL.\end{cases}$$

LEMMA III.

If a Series of Squares, whoſe Sides or Roots are in arithmetical Progreſſion, beginning with a Cypher, *&c.* be infinitely continued, the laſt Term being multiplied into the Number of Terms, will be triple

to

to the Sum of all the Series; *viz.* NLL$=3$S; or $\frac{1}{3}$ NLL$=$S.

That is, the Sum of fuch a Series will be One-third of the laft or greateft Term, fo many times repeated as there are Numbers of Terms in their Series.

Inftances in fquare Numbers.

1 $\left\{\dfrac{0+1+4}{4+4+4}=\frac{5}{12}=\frac{1}{3}+\frac{1}{12}.\right.$

2 $\left\{\dfrac{0+1+4+9}{9+9+9+9}=\frac{14}{36}=\frac{7}{18}=\frac{1}{3}+\frac{1}{18}.\right.$

3 $\left\{\dfrac{0+1+4+9+16}{16+16+16+16+16}=\frac{30}{80}=\frac{3}{8}=\frac{9}{24}=\frac{1}{3}+\frac{1}{24},\right.$ &c.

From thefe Inftances it is evident, that as the Number of Terms in the Series do increafe, the Fraction or Excefs above $\frac{1}{3}$ does increafe, the faid Excefs always being $\dfrac{1}{6N-6}$; which, if we fuppofe the Series to be infinitely continued, will quite vanifh, and become nothing at all.

LEMMA IV.

If a Series of Cubes, whofe Roots are in arithmetical Progreffion, beginning with a Cypher, &c. (as above) be infinitely continued, the Sum of all the Series will be $\frac{1}{4}$ NLLL$=$S.

That is, One-fourth of the laft Term fo many times repeated as there are Numbers of Terms.

Inftances

Inftances in cube Numbers.

If 0, 1, 2, 3, 4, 5, *&c.* be the Roots of the Cubes,

$$1 \left\{ \frac{0+1+8+27}{27+27+27+27} = \frac{36}{108} = \frac{4}{12} = \frac{1}{4} + \frac{1}{12}. \right.$$

$$2 \left\{ \frac{0+1+8+27+64}{64+64+64+64+64} = \frac{100}{320} = \frac{10}{32} = \frac{5}{16} = \frac{1}{4} + \frac{1}{16}. \right.$$

$$3 \left\{ \frac{0+1+8+27+64+125}{125+125+125+125+125+125} = \frac{125}{750} = \frac{45}{150} \right.$$

$$(= \frac{3}{20} = \frac{1}{4} = \frac{1}{20}.$$

From thefe Examples it plainly appears, that as the Number of Terms in the Series increafes, the Fraction or Excefs above $\frac{1}{4}$ decreafes, the Excefs being always $\frac{1}{4N-4}$; which, if we fuppofe the Series to be infinitely continued, will become infinitely fmall, or nothing.

LEMMA V.

If a Series of Biquadrates, whofe Roots are in arithmetical Progreffion, beginning with a Cypher, *&c.* as before, be infinitely continued, the Sum of all the Terms in fuch a Series will be $\frac{1}{5}$ NLLLL.

The Truth of this may be manifefted by the like Procefs as in the foregoing Lemmas, and fo on for higher Powers.

LEMMA VI.

The Sum of an infinite Progreffion, whofe greateft Term is a fquare Number, the other decreafing by odd Numbers; *viz.* 1, 3, 4, *&c.* is in fubfefquialteran Proportion of the Sum of the like Number of equal Terms, that is, as 2 to 3.

Inftances

Inſtances in ſuch Progreſſions.

1 $\left\{\frac{9+8+5}{9+9+9}\right. = \frac{22}{27} = \frac{2}{3} + \frac{4}{9}.$

2 $\left\{\frac{16+15+12+7}{16+16+16+16}\right. = \frac{50}{64} = \frac{2}{3} + \frac{15}{32}.$

3 $\left\{\frac{25+24+21+16+9}{25+25+25+25+25}\right. = \frac{95}{125} = \frac{2}{3} = \frac{7}{27}.$

4 $\left\{\frac{36+35+32+27+20+11}{36+36+36+36+36+36}\right. = \frac{161}{216} = \frac{2}{3} + \frac{17}{72}.$

From theſe Examples it plainly appears, that as the Number of Terms in the Series increaſes, the Fraction or Exceſs above $\frac{2}{3}$ decreaſes; and if we ſuppoſe the Series to be infinitely continued, that Exceſs will quite vaniſh, and the Sum of the infinite Series will be $\frac{2}{3}$ of ſo many equal to the greateſt.

N CHAP.

CHAP. II.

The Mensuration of Solids.

SOLID Bodies are such as do consist of Length, Breadth, and Thickness; as Stone, Timber, Globes, Bullets, &c.

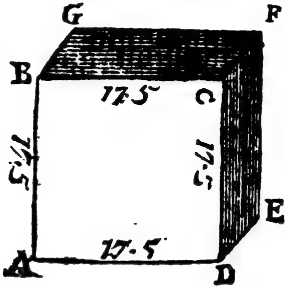
§ I. *Of a* Cube.

A CUBE is a square Solid, comprehended under six geometrical Squares, being in the Form of a Dye. To find the solid Content, this is

The RULE.

Multiply the Side of the Cube into itself, and that Product again by the Side; the last Product will be the Solidity, or solid Content of the Cube.

```
   175
   17.5
  ------
   875
  1225
  175
  ------
  306.25
   17.5
  ------
  153125
 214375
 30625
 --------
5359 375
```

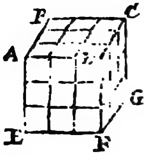


5359 375 the folid Content of the Cube.

Suppofe ABCDEFG a cubical Piece of Stone or Wood, each Side thereof being 17 Inches and an half; multiply 17.5 by 17.5, and the Product is 306.25; which being multiplied by 17.5, the laft Product is 5359.375, which is 5359 folid Inches and 375 Parts. To reduce the folid Inches to Feet, divide by 1728 (becaufe fo many cubical Inches is a Foot), and the folid Feet in the Cube will be 3, and 175 cubical Inches remain.

By Scale and Compaffes.

Extend the Compaffes from 1 to 17.5; that Extent turned over twice from 17.5 will reach to 5359, the folid Content in Inches. Then extend the Compaffes from 1728 to 1; that Extent, turned the fame Way from 5359, will reach to 3.1 Feet.



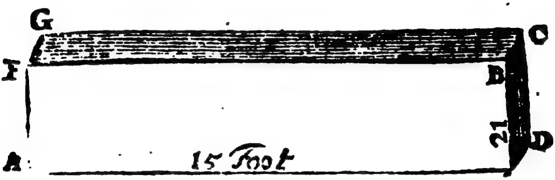
Demonftration. If the Square ABCD be conceived to be moved down the Plane ADEF, always remaining parallel to itfelf, there will be generated, by fuch a Motion, a Solid, having fix Planes, the two oppofite whereof will be equal and parallel to each other; whence it is called a Parallelopipedon, or fquare Prifm. And if the Plane ADEF be a Square equal to the penetrating Plane ABCD, then will the generated Solid be a Cube. From hence fuch Solids may be conceived to be conftituted of an infinite Series of equal Squares, each equal to the Square ABCD; and AE or DF will be the Number of Terms. Therefore, if the Area of ABCD be multiplied into the Number of Terms AE, the Product is the Sum of all the Series, (*per* Lemma I.) and, confequently, the Solidity of the Parallelopipedon or Cube. Or, if the Bafe ABCD, being divided into little fquare Areas, be multiplied into the Height AE, divided by a like Meafure for Length, after this Way you may conceive as many little Cubes to be generated in the whole Solid, as is the Number of the little Areas of the Bafe multiplied by the Number of Divifions the Side AE contains. Thus, if the Side of the Bafe AB be 3, that multiplied into itfelf is 9, which is the Area of the fquare Bafe ABCD; then, if AE be likewife 3, multiply 9 by 3, and the Product is 27; and fo many little Cubes will this Solid be cut into, if you conceive it to be cut as the Lines direct.

From this Demonftration it is very plain, that, if you multiply the Area of the Bafe of any Parallelopipedon into its Length or Height, that Product will be the folid Content of fuch a Solid.

§ II.

§ II. *Of a* PARALLELOPIPEDON.

LET ABCDEFG be a Parallelopipedon, or square Prism, representing a square Piece of Timber or Stone, each Side of its square Base ABCD being 21 Inches, and its Length AE 15 Feet.



First, then, multiply 21 by 21, the Product is 441, the Area of the Base in Inches; which multiplied by 180, the Length in Inches, and the Product is 79380, the solid Content in Inches. Divide the last Product by 1728, and the Quotient is 45.9, that is, 45 solid Feet and 9 Tenths of a Foot. Or thus: Multiply 441 by 15 Feet, and the Product is 6615; divide this by 144, and the Quotient is 45.9, the same as before.

Or thus, by multiplying Feet and Inches.

Multiply 1 Foot 9 Inches by 1 Foot 9 Inches, and the Product is 3 Feet 0 Inches 9 Parts; this multiplied again by 15 Feet, gives 45 Feet 11 Inches 3 Parts, that is, 45 Feet and $\frac{11}{12}$ of a Foot and $\frac{1}{4}$ of $\frac{1}{12}$.

See the Work of all these.

21
21
———
21
42
———
441
180
———
35280
441
———
1728)79380(45.9
6912
———
10260
8640
———
16200
15552
———
648

441
15
———
2205
441
———
144)6615(45.9
———
855
1350
———
.54

F. I.
1—9
1—9
———
1—9
1—3—9
———
3—0—9
15
———
45—0—0
7—6
3—9
———
45—11—3

By Scale and Compaffes.

Extend the Compafies from 12 to 21, and that Extent will reach to near 46 Feet, being twice turned over from 15 Feet; fo the folid Content is almoft 46 Feet.

If the Bafe of the fquared Solid be not an exact Square, but in Form of a rectangle Parallelogram, the Way of meafuring it is much the fame; for, firft, you muft find the Area of the Bafe by multiplying the Breadth by the Depth; and then multiply that Area by the Length of the Piece, as before. Thus,

If a Piece of Timber be 25 Inches broad, 9 Inches deep, and 25 Feet long, how many ſolid Feet are contained therein?

25	F. I.
9	2—1
——	0—9
225	——
25	1—6—9
——	25
1125	——
450	25—0—0
——	12—6—0
144)5625(39	1—0—6
432	0—6—3
——	——
1305	39—0—9
1296	
——	
9	Anſwer 39 Feet.

By Scale and Compaſſes.

Firſt, find a mean geometrical Proportion between the Breadth and the Depth; which to do upon the Line of Numbers, you muſt divide the Space upon the Line, between the Breadth and Depth, into two equal Parts; that middle Point will be the mean Proportional ſought: Thus the middle Point between 25 and 9 is at 15; ſo is 15 a mean Proportional between 9 and 25, for 9 : 15 : : 15 : 25; ſo a Piece of Timber of 15 Inches ſquare is equal to a Piece 25 Inches broad and 9 Inches deep. So then, if you extend the Compaſſes from 12 to 15, that Extent, turned twice over from 25 Feet, the Length, will reach to 39 Feet, the Content.

§ III.

§ III. *Of a Triangular* Prism.

A Prifm is a Solid contained under feveral Planes, and having its Bafes like, equal, and parallel. The folid Content of a Prifm (whether triangular or multangular) is found by multiplying the Area of the Bafe into the Length or Height, and the Product is the folid Content.

Let ABCDEF be a triangular Prifm, each Side of the Bafe being 15.6 Inches, the Perpendicular thereof C *a* is 13.51 Inches, and the Length of the Solid 19.5 Feet.

Multiply the Perpendicular of the Triangle 13.51 by half the Side 7.8, and the Product is 105.378, the Area of the Bafe; which multiply by the Length 19.5, and the Product is 2054.871; which divide by 144, and the Quotient is 14.27 Feet *ferè*, the folid Content.

```
    13.51     144)2054.87(14.27
      7.8         144
   -------        ----
    10808          614
    9457           576
   -------        ----
   105.378          388
      19.5          288
   -------         ----
    526890          1007
   948402           1008
  105378
 ---------
 2054.8710
```

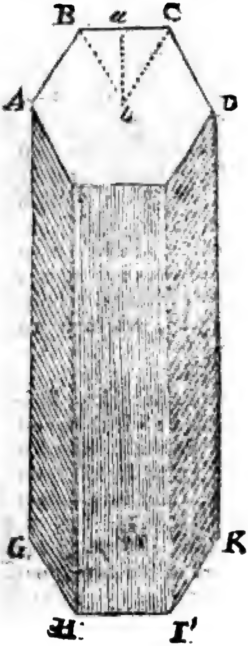
By

By Scale and Compasses.

First, find a mean Proportional between the Perpendicular and Half-side (as before taught), by dividing the Space upon the Line, between 13.51 and 7 8 into two equal Parts; so shall you find the middle Point between them to be at 10 26, which is the mean Proportional sought: By this means the triangular Solid is brought to a square one, each Side being 10 26 Inches. Then extend the Compasses from 12 to 10.26; that Extent, turned twice downwards from 19.5 Feet, the Length will at last fall upon 14.27, which is 14 Feet and a little above a Quarter.

Let ABCDEFGHIK represent a Prism, whose Base is a Hexagon, each Side thereof being 16 Inches, and the Perpendicular from the Center of the Base to the Middle of one of the Sides (a b) is 13.14 Inches, and the Length of the Prism is 15 Feet; the solid Content is required.

Multiply half the Sum of the Sides 48 by 13.84, and the Product is 664 32, the Area of the hexagonal Base (by § VIII. *p.* 86), which multiplied by 15 Feet, the Length, the Product is 9964.8; which divided by 144, the Quotient will be 69.2 Feet, the solid Content required.




```
   13.84
      48
  ------
   11072
   5536
  ------
  664.32 Ar. of Base.
      15
  ------
  332160
  66432
  ------
144)9964.80(69.2
    864
    ----
    1324
    1296
    ----
     288
     288
    ----
     ..
```

By Scale and Compasses.

First, find a mean Proportional between the Perpendicular, and half the Sum of the Sides; that is, divide the Space between 13.84 and 48, and the middle Point will be 25.77. Then extend the Compasses from 12 to 25.77; that Extent will reach (being twice turned over) from 15 Feet, the Length, to 69.2 Feet, the Content.

To find the superficial Content of any of the forementioned Solids, you must take the Girth of the Piece, and multiply by the Length, and to that Product add the two Areas of the Bases, the Sum will be the whole superficial Content. Example of the hexagonal Prism last mentioned. The Sum of the Sides being 96, and the Length 15 Feet, that is, 180 Inches; which multiplied by 96, the Product is 17280 square Inches; to which add twice 664.32, the Areas of the two Bases, the Sum is 18608.64, the Area of the Whole, which is 129.22 Feet.

```
        180
         96
       ----
       1080
      1620
     ------
     17280
       664.32
       664.32
    ----------
144)18608.64(129.22
     ---
     420
     1328
       326
        384
       ----
         96
```

The superficial Content of the whole Solid is 129.22 Feet.

By Scale and Compasses.

Extend the Compasses from 144 to 180; that Extent will reach from 96 to 120 Feet. Then, to find the Area of the Base, extend the Compasses from 144

to

to 13.84; that Extent will reach from 48 to 4.6 Feet; add 120 Feet, and twice 4.6 Feet, and it makes 129.2 Feet, the fuperficial Content, as before.

The Demonftration of thofe laft Solids will be the fame as in the firft Section; for as in that, fo in thefe, the Area of the Bafe is multiplied into the Length to find the Content, and the fame Reafon is given for one as for the other.

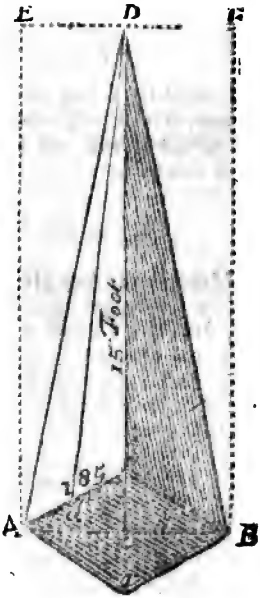
§ IV: *Of a* PYRAMID.

A Pyramid is a folid Figure, whofe Bafe is a Polygon, and whofe Sides are plain Triangles, their feveral Tops meeting together in one Point. To find the folid Content thereof, this is

The RULE.

Multiply the Area of the Bafe by a third Part of the Altitude, or Length; and the Product is the folid Content of the Pyramid.

Let



Let A B D be a square Pyramid, each Side of the Base being 18.5 Inches, and the perpendicular Height CD is 15 Feet: Multiply 18.5 by 18.5, and the Product is 342.25, the Area of the Base in Inches; which, multiplied by 5, a third Part of the Height, and the Product is 1711.25; this divided by 144, the Quotient is 11.88 Feet, the solid Content.

```
  18.5
  18.5
  ----
   925
  1480
  185
  ------
  342.25 Area of the Base.
       5
  ------
144)1711.25(11.88 Content.
```

```
F.  I.  Pts.
1   6   6
1   6   6
-----------
1   6   6
    9   3
        9   3
---------------
2   4   6   3
            5
---------------
11  10  7   3
```

By Scale and Compaſſes.

Extend the Compaſſes from 12 to 18.5 Inches, that Extent, turned twice over from 5 Feet (a third Part of the Height), will fall at laſt upon 11.88 Feet, the ſolid Content.

To find the ſuperficial Content.

Multiply the ſlant Height (or Perpendicular of one of the Triangles) by half the Periphery of the Baſe 37, and the Product is 6668.88; which divided by 144, the Quotient is 46.31 Feet, the ſuperficial Content of all but the Baſe; then to that add 2.38 Feet, the Baſe, and it makes 48.69 Feet, the whole ſuperficial Content.

```
180.24 the ſlant Height dD.
    37
 ------
126168
54072
 -------
844)6668.88(46.31
    576        2.38
    ---        ----
     908       48.69 the whole Content.
     864
     ---
      448
      432
      ---
       168
       144
       ---
        24
```

```
144)342.25(2.38
    288
    ---
     542
     432
     ---
     1105
     1152
```

By

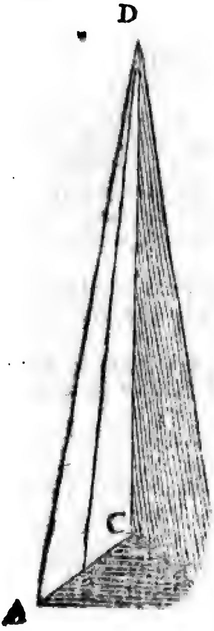
By Scale and Compaſſes.

Extend the Compaſſes from 144 to 180.24, that Extent will reach from 37 to 46 31 Feet, the Area of the four Triangles; and extend the Compaſſes from 144 to 18.5; (one Side of the Baſe), that Extent will reach from 18.5 to 2 38 *fere:* Which added to the other, the Sum is 48 69, the whole Superficies.

Demonſtration. Every Pyramid is a third Part of the Priſm, that hath the ſame Baſe and Height (by *Eucl.* 12.7.)

That is, the ſolid Content of the Pyramid A B D (in the laſt Figure) is one third Part of its circumſcribing Priſm ABEF.

For every Pyramid that hath a ſquare Baſe (ſuch as Aa Bb in the laſt Figure) is conſtituted of an infinite Series of Squares, whoſe Sides or Roots are continually increaſing in arithmetical Progreſſion, beginning at the Vertex or Point D, its Baſe Aa Bb being the greateſt Term, and its perpendicular Height CD is the Number of all the Terms: But the laſt Term multiplied into the Number of Terms, the Product will be triple the Sum of all the Series (by Lemma 3.); conſequently $\frac{NLL}{3}=S$. And S is equal to the ſolid Content of the Pyramid. From hence it will be eaſy to conceive, that every Pyramid is $\frac{1}{3}$ of its circumſcribing Priſm (that is, of a Priſm of equal Baſe and Altitude), what Form ſoever its Baſe is of; *viz.* whether it be ſquare, triangular, pentangular, *&c.* You may very eaſily prove a triangular Pyramid to be a third Part of a Priſm of equal Baſe and Altitude, by cutting a triangular Priſm of Cork, and then cut that Priſm into three Pyramids, by cutting diagonally, as I have ſeveral times done, to ſatisfy myſelf and others.



Let ABCD be a triangular Pyramid, each Side of the Baſe being 21.5 Inches, and its perpendicular Height 16 Feet; the Content, ſolid and ſuperficial, is required.

Firſt, find the Area of the Baſe, by multiplying half the Side of the Perpendicular let fall from the Angle of the Baſe to the oppoſite Side; which Perpendicular will be found to be 18.62; the Half thereof is 9.31, multiplied by 21.5, the Product is 200.165 Inches, the Area of the Baſe. Then, becauſe the Altitude 16 cannot exactly be divided by 3, therefore I take the third Part of 200.165, which is 66.72, and multiply it by 16, and the Product is 1067.52; which divided by 144, the Quotient is 7.41 Feet, the ſolid Content.

```
          9.31 half the Perpend.
          21.5 the Side.
          ----
          4655
          931
         1862
        ------
      3)200.165 Area Base.
        -------
         66.72 a third Part.
            16 Height.
        -------
         40032
         6672
       --------
  144)1067.52(7.41 Solid Cont.
      1008
      ----
        595
        576
        ---
         192
         144
         ---
          48
```

	F.	I.	Pts.	
Side	1	6	6	
Half Perp.		9	4	
	1	4	1	6
			7	2
Area Base	1	4	8	8
				4
	5	6	10	8
				4
	3)22	3	6	8
Cont.	7	5	2	2

In casting this up by Feet and Inches, instead of multiplying by 16, the Height, I break 16 into two such Numbers, as, being multiplied together, the Product may be 16; *viz.* into 4 and 4, and multiply first by one, and then the other; a third Part of the last Product is the Content.

By Scale and Compasses.

First, find a geometrical mean Proportional (as before directed), by dividing the Space between 21.5 and 9.31 into two equal Parts, and you will find the middle Point at 14.15, which is the mean Proportional sought. Then extend the Compasses from 12 to

14.15, that Extent (turned twice over from 16 Feet) will fall at last upon 22.23; a third Part thereof is 7 41 Feet, the Content.

To find the superficial Content.

Multiply the slant Height (or Perpendicular of one of the Triangles) by half the Periphery of the Base, and to that Product add the Area of the Base, the Sum is the whole superficial Content.

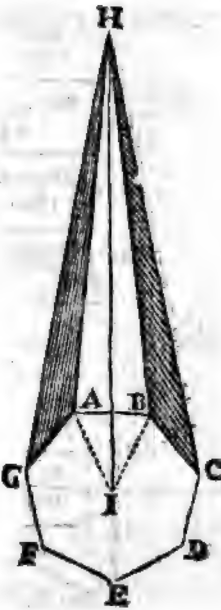
```
               192.1 Inches, the slant Height d D.
HalfPeriph.  32.25=21.5+1075
            ------
              9605
             3842
            3842
           5763
          -------
           6195.225 Inches, the Area of all but the
            200.165 Area of the Base add.        (Base.
          ---------
       144)6395.390(44.41 Feet, the whole Content.
           576
           ---
            635
            576
            ---
             593
             576
             ---
              179
              144
              ---
               35
```

By Scale and Compasses.

Extend the Compasses from 144 to 192.1, that Extent will reach from 32.25 (half the Periphery of the Base) to 43.02 Feet, the Content of the upper Part.

And

And extend the Compasses from 144 to half the Perpendicular 9.31, that Extent will reach from the Side 21.5 to 1.39 Feet, the Area of the Base; which, added to the other, makes 44.41 Feet, the Contents of the Whole.



Let ABCDEFGH be a Pyramid, whose Base is a Heptagon, each Side thereof being 15 Inches, and the Perpendicular of the Heptagon is 15.58 Inches, and the perpendicular Height of the Pyramid HI is 13.5 Feet; the Content, solid and superficial, is required.

Multiply 15.58 (the Perpendicular) by 52.5 (half the Sum of the Sides of the Heptagon) and the Product is 817.95; which multiplied by 4.5, *viz.* $\frac{1}{3}$ of the Height, and the Product is 3680.775.

The

Then divide this last Product by 144, and the Quotient is 25.56 Feet, the Content.

```
         15.58 the Heptagon's Perpend.
          52.5 the Half-Sum of the Sides.
         -----
          7790
         3116
        7790
       -------
        817 950
            4.5 a third Part of the Height.
       --------
       .4089750
       3271800
       --------
144)3680.7750(25.56 Solid Feet.
    288
    ---
     800
     720
     ---
      807
      720
      ---
       877
       864
       ---
        13
```

By Scale and Compasses.

First, find a geometrical mean Proportional between 15.58 and 52.4 (as is before directed), which you will find to be 28.06; then extend the Compasses from 12 to 28.06, that Extent will reach from 4.5 (twice turned over) to 25.56 Feet.

To

To find the superficial Content.

Multiply the Height taken from the Middle of one of the Sides of the Base 162.75 Inches, by the Half-Sum of the Sides 52.5 Inches, and the Product is 8544.375; which divided by 144, the Quotient is 59.335 Feet, the Content of the upper Part.

```
        162.75              144)817.95(5.68
          52.5                 -------
       -------                   979
        81375                    1155
       32550                     ----
      81375                         3
     ----------
144)8544.375(59.335 Feet.
    ----         5.68  Base add.
    1344       -------
     483       63.015 the whole Content.
      517
       855
       ----
        135
```

By Scale and Compasses.

Extend the Compasses from 144 to 162.75, that Extent will reach from 52.5 to 59.335 Feet.

And extend the Compasses from 144 to 15.58, the Perpendicular of the Heptagon, that Extent will reach from 5.25 to 5.68 Feet, the Content of the Base; which add to the former, the Sum is 65.015, the whole superficial Content.

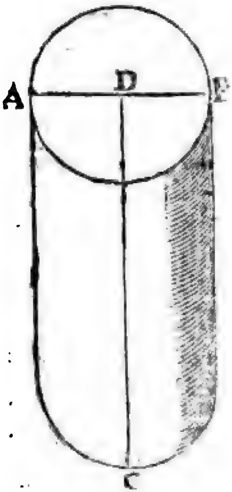
§ V.

§ V. *Of a* CYLINDER.

A Cylinder is a round Solid, having its Bafes circular, equal, and parallel, in Form of a Rolling-ftone ufed in Gardens. To find the folid Content thereof, this is

The RULE.

Multiply the Area of the Bafe by the Length, and the Product is the folid Content.



Let A B C be a Cylinder, whofe Diameter A B is 21.5 Inches, and the Length C D is 16 Feet; the folid Content is required.

Firft, fquare the Diameter 21.5, and it makes 462.25; which multiplied by .7854, and the Product is 363 05115. Then multiply this by 16, and the Product is 5808 8164. Divide this laft Product by 144, and the Quotient is 40 34 Feet, the folid Content.

By Scale and Compaffes.

Extend the Compaffes from 13.54 to 21.5, the Diameter, that Extent (turned twice over from 16, the Length) will at laft fall upon 40.34, the folid Content.

To

To find the fuperficial Content.

Firft (by Chap. I. Sect. IX. Prob. 2.), find the Circumference of the Bafe 67.54, which multiplied by 16, the Product is 1080.64; which divided by 12, the Quotient is 90.05 Feet, the curve Surface; to which add 504 Feet, the Sum of the two Bafes, and the Sum is 95.09 Feet, the whole fuperficial Content.

67.54		363.05
16		2
40524		144)726.10(5.04
6754	90.05 } add.	610
12)1080 64	5.04 }	34
90.05	95.09	

By Scale and Compaffes.

Extend the Compaffes from 12 to 67.54 (the Circumference), that Extent will reach from 16 (the Length) to 91.05 Feet, the curve Surface.

And extend the Compaffes from 12 to 21.5 (the Diameter), that Extent (turned twice from .7854) will at laft fall upon 2.52 Feet, the Area of the Bafe; which doubled is 504; this, added to the curve Surface, makes 95 09 Feet, the whole fuperficial Content.

Demonftration. The folid Content of every Cylinder is found, by multiplying the Area of its Bafe into its Height, as aforefaid: For every right Cylinder is only a round Prifm, being conftituted of an infinite Series of equal Circles; that of its Bafe, or End, being one of the Terms, and its Height CD (in the former Figure) is the Number of all the Terms. Therefore the Area of its Bafe AB, being multiplied into CD,

CD, will be its Solidity (by Lemma I.) Let D= AB, H=CD.

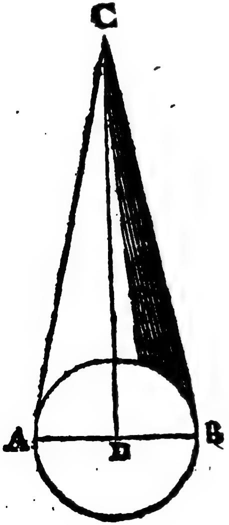
Then $.7854\ DD \times H =$ its Solidity.

§ VI. *Of a* Cone.

A Cone is a Solid, having a circular Base, and growing smaller and smaller, till it ends in a Point which is called the Vertex, and may be nearly represented by a Sugar-loaf. To find the Solidity thereof, this is

The RULE.

Multiply the Area of the Base by a third Part of the perpendicular Height, and the Product is the solid Content.



Let ABC be a Cone, the Diameter of whose Base AB is 26.5 Inches, and the Height of the Cone DC is 16.5 Feet: First, square the Diameter 26.5, and it is 702.25, which multiply by .7854, and the Product is 551.54715; which multiply by 5.5, and the Product is 3033.47825; which divided by 144, the Quotient is 21.07 *fere*, the solid Content of the Cone.

26.5

```
        26.5 the Diameter.
        26.5
        ----
        1325
       1590
       530
      ------
      702.25 the Square.
       .7854
      ------
      280900
     351125
    561800
   491575
   ---------
   551.54|715 Area of the Baſe.
       5.5      a third Part of the Height.
   ---------
    275770
   275770
   ---------
144)3033.47|0(21.06 Feet, the Content.
    ---
     153
      947
      ---
       83
```

By Scale and Compaſſes.

Extend the Compaſſes from 13.54 to 26.5, the Diameter, that Extent turned twice over from 5.5 (a third Part of the Height), it will at laſt fall upon 21.06 Feet, the Content.

To find the ſuperficial Content.

Multiply half the Circumference 41.626 by the ſlant Height AC 198.46, and the Product is 8261.09596; which divided by 144, the Quotient is 57.37 *ferè*, the curve Surface; to which add the Baſe, the Sum is 61.2, the ſuperficial Content.

```
       41.626 half Circumference of the Base.
      198.46 the slant Height.
      ------
       249756
      166504
     333008
    374634
    41626
   ----------
144)8261.09596(57.37 Feet fere.
   ----          3.83 the Base add.
   1061         ------
     530        61.20 the whole Content.
      989
   ------
144)551.54(3.83
   ----
   1195
     434
   -----
       2
```

By Scale and Compasses.

Extend the Compasses from 144 to 198.46, that Extent will reach from 41.626 to 57.37 Feet, the curve Surface.

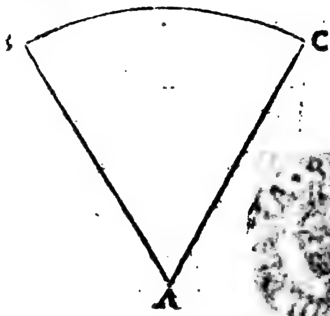
And extend the Compasses from 12 to 26.5, the Diameter; that Extent, turned twice over from .7854, will at last fall upon 3.83 Feet, the Base; which added to 57.37, the Sum is 61.2 Feet, the superficial Content.

Demonstration. Every Cone is the Third Part of a Cylinder of equal Base and Altitude. The Truth of this may easily be conceived, by only considering, that a Cone is but a round Pyramid; and therefore it must needs have the same Ratio to its circumscribing Cylinder, as the square Pyramid hath to its circum-

ſcribing Parallelopipedons; *viz.* as 1 to 3. However, to make it yet clearer, let it be farther conſidered, That

Every right Cone is conſtituted of an infinite Series of Circles, whoſe Diameters do continually increaſe in arithmetical Progreſſion, beginning at the Vertex, or Point C, the Area of its Baſe AB being the greateſt Term, and its perpendicular Height DC, the Number of all the Terms; therefore the Area of the Circle of the Baſe, multiplied by a third Part of the Altitude DC, will be the Sum of all the Series, equal to the Solidity of the Cone, by Lemma III.

* The curve Superficies of every right Cone is equal to half the Rectangle of the Circumference of its Baſe into the Length of its Side.



For the curve Surface of every right Cone is equal to the Sector of a Circle, whoſe Arch BC is equal to the Periphery of the Baſe of the Cone, and Radius AB equal to the ſlant Side of the Cone: Which will appear very evident, if you cut a Piece of Paper in the Form of a Sector of a Circle, as ABC, and bend the Sides AB and AC together, till they meet, and you will find it to form a right Cone. *

I have omitted the Demonſtrations touching the Superficies of all the foregoing Solids, becauſe I thought it needleſs, they being all compoſed of Squares, Parallelograms, Triangles, &c. which Figures are all demonſtrated before. And if the Area of all ſuch Fi-

gures as compoſe the Solid, be found ſeverally, and added together, the Sum will be the ſuperficial Content of the Solid.

§ VII. *Of the Fruſtum of a* Pyramid.

A Fruſtum of a Pyramid is the remaining Part, when the Top is cut off by a Plane parallel to the Baſe. To find the ſolid Content thereof, there are ſeveral Rules.

RULE I.

To the Rectangle (or Product) of the Sides of the two Baſes add the Sum of their Squares; that Sum, being multiplied into One-third Part of the Fruſtum's Height, will give its Solidity, if the Baſes be ſquare.

Or thus; which is the ſame in Effect:

Multiply the Areas of the two Baſes together, and to the ſquare Root thereof add the two Areas; that Sum, multiplied by One-third of the Height, gives the Solidity of any Fruſtum, ſquare or multangled.

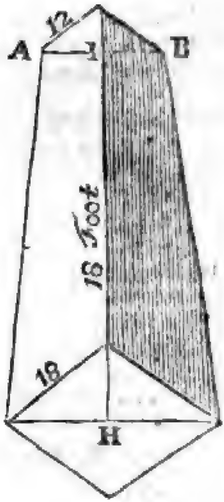
RULE II.

To the Rectangles of the Sides of the two Baſes, add one third Part of the Square of their Difference; that Sum, being multiplied into the Height, will produce the Solidity, if the Baſes be Squares: But if they be triangular or multangular, the ſaid Rectangle of the Sides, with the third Part of the Square of their Difference, will be the Square of a mean Side; and the ſquare Root thereof will be ſuch a mean Side

as,

as will reduce the tapering Solid to a Prifm equal thereunto.

Example. Let A B C D be the Fruftum of a fquare Pyramid, the Side of the greater Bafe 18 Inches, and the Side of the leffer 12 Inches, and the Height 18 Feet; the Solidity thereof is required.



Firft, multiply the two Sides together, 18 by 12, and the Product is 216, and the Difference of the Sides is 6, whofe Square is 36, a third Part thereof is 12, which added to 216, the Sum is 228 Inches, the Area of a mean Bafe; which multiplied by 18 Feet, the Length, the Product is 4104; this divided by 144, the Quotient is 28.5 Feet, the Content.

Or, by the firft Rule, thus: The Square of 18 is 324, and the Square of 12 is 144, and the Rectangle of 18 by 12 is 216; the Sum of thefe three is 684, which multiplied by 6, the Product is 4104; which divided by 144, the Quotient is 28.5 Feet, the fame as before.

See the Work, both Ways.

18	6	Diff.
12	6	
216	3)36	Square.
12 add	12	a Third.
228		the Sum.
18		the Height.
1824		
228		
144)4104(28.5		
1224		
720		
...		

18	12	
18	12	
324 Sq.	144 Sq.	
144		
216		
684		the Sum.
6		a 3d of the Height.
144)4104(28.5		Feet.
1224		
720		
...		

By Feet and Inches, thus:

	F.	I.	I.	
Mult.	1	6	6	
by	1		6	
Prod.	1	6	3)36q.	
add	0	1	12	
Mult.	1	7		
by	18	0		Height.
	18	0		
	9	0		
	1	6		
Cont.	28	6		

Or thus:

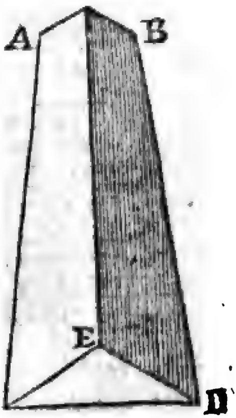
F.	I.	
2	3	Sq. of the greater.
1	6	the Rectangle.
1	0	Square of the less.
4	9	Trip. of a mean Ar.
6	0	a 3d of the Height.
28	6	

To

To find the ſuperficial Content.

The Perimeter of the greater Baſe is 72, and the Perimeter of the leſſer Baſe is 48; add both the Perimeters together, the Sum is 120; the half thereof is 60; which multiplied by 18 Feet, the Product is 1080; this divided by 12, the Quotient is 90 Feet; to which add the two Baſes 2.25 Feet, and 1 Foot; the Sum is 93.25 Feet, the whole ſuperficial Content.

18	12	18 the Height.
4	4	60
72	48	12)1080
48		90 Feet.
2)120		2.25 the greater Baſe.
60		1 the leſſer Baſe.
		93.25 the Sum.



Again: Let ABC be the Fruſtum of a triangular Pyramid, each Side of the greater Baſe 25 Inches, and each Side of the leſſer Baſe 9 Inches, and the Length 15 Feet; the ſolid Content thereof is required.

By the ſecond Rule, multiply 25 by 9, and the Product is 225; and the Difference between 25 and 9 is 16, which ſquared, makes 256; a third Part thereof is 85.333, which added to 225, the Sum is 310.333; and this multiplied by

433;

433, the Product is 134.374, &c. which is the Area of a mean Bafe; and that multiplied by 15 Feet, the Length, the Product is 2015.610; which divided by 144, the Quotient is 13.99 Feet, the Solidity.

Or thus, by the latter Part of the firft Rule: Find the Area of the greater Bafe, which you will find to be 270.625, and the Area of the leffer Bafe will be 35.073; thefe two Areas multiplied together, the Product is 9491.630625; the Square Root thereof is 97.425; to which add the two Areas, and the Sum is 403.123; which multiplied by a third Part of the Length, 5, the Product is 2015.615; and that divided by 144, the Quotient is 13.99 Feet, as before.

See the Working of both.

```
           25      25
            9       9
Product   225      16  Diff.
                   16
                   96
                  16
                3)256  the Square.
                  85.333   a third Part.
                  225      add.
                  310.333
                      433  tabular Number, p. 89.
                   930999
                  930999
                 1241332
                 134.374189  mean Area.
                         15  Length.
                 671.870945
                1343.74189
          144)2015.61|2835(13.99 Feet.
                575
                1436
                 1401
                  105
```

```
   25
   25
  ———
  125
  50
  ———
  625 Square.
  433
 ————
 1875
1875
2500
——————
270.625 Area.

 9
 9
——
81 Square.

   433
    81
  ————
   433
  3464
 ——————
 35.073

    270.625
     35.073
   ————————
     811875
    1894375
  13531250
  811875
 ———————————
 9491.630625

 9491.630625(97.425
 81
 ——
187)1391
    1309
   —————
1944)8263
     7776
    —————
19482)48706
      38964
     ——————
194845)974225
       974225
      ———————
       ......
```

270.625	greater Area.
97.425	the mean Proportional.
35.073	the leffer Area.
403.124	the Triple of a mean Area.
5	a third Part of the Height.

144)2015.615(13.99 Feet, the Solidity.

575
1436
1401

105

In finding the Area of the triangular Bafe, I multiply by 433, becaufe that is the Area of the equilateral Triangle, when the Side thereof is 1. A Table of the Areas, or Multipliers, for finding the Areas of Polygons, you'll find in *p.* 89.

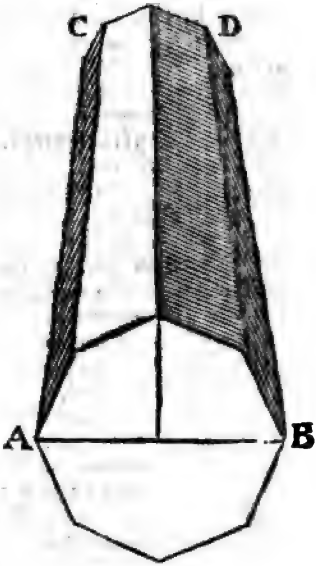
Multiply the Square of the Side by the tabular Number, and the Product is the Area of the Polygon.

To find the fuperficial Content.

The Perimeter of the greater Bafe is 75, and the Perimeter of the leffer Bafe is 27; the Sum of both is 102, and the Half Sum is 51; which multiplied by 15 Feet, the Product is 765; which divided by 12, the Quotient is 63.75; to which add the Sum of the two Bafes 2.12 Feet, and the Sum is 65.87 Feet, the whole fuperficial Content.

Note, That 51 fhould have been multiplied by the flant Height, but the Difference it would make is but .06 of a Foot, which is inconfiderable.

Again:



Again: Suppoſe ABCD to be the Fruſtum of a Pyramid, having an octagonal Baſe, each Side thereof being 9 Inches, and each Side of the leſſer Baſe 5 Inches, and the Length, or Height, 10.5 Feet; the Solidity is required.

By the ſecond Rule multiply the greater Side 9 by the leſſer Side 5, and the Product is 45; then the Difference between 9 and 5 is 4; which ſquared makes 16; a third Part thereof is 5.3333, which added to 45, the Sum is 50.3333; multiply this laſt by the Number in the Table 4.8284, and the Product is 243.0292, the Area of a mean Baſe; which multiplied by the Height 10.5 Feet, the Product is 2551.8066; then divide this laſt Product by 144, and the Quotient is 17.72 Feet, the ſolid Content.

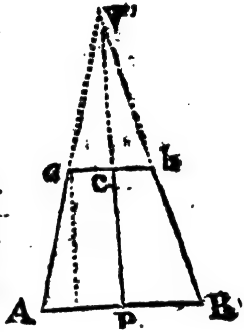
See the Work.

```
Mult. 9 Inches.   9 from the greater Side.
  by  5 Inches.   5 subtract the lesser.
      ---         -
Prod. 45          4
                  4
                 ---
               3)16 squared.
                 -
                 5.3333 a third Part.
           Add  45
                -------
           Sum  50.3333 the Sq. of a mean Side
                 4.8284 tabular Number, p. 8
                -------
                2013332
                 402666
                  10067
                   4026
                    201
               --------
               243.0292 a mean Area.
                   10.5 the Height.
               --------
               12151460
              2430292
              ---------
         144)2551.80|660(17.72
              144
              ----
              1111
              1008
              ----
               1038
               1008
              -----
                300
                288
                ---
                 12
```

To find the superficial Content.

The Perimeter of the greater Base is 72, and the Perimeter of the lesser Base is 40, and their Sum is 112; the Half thereof is 56, which multiplied by the Height 10.5 Feet, and the Product is 588; which divided by 12, the Quotient is 49 Feet; to which add the Sum of the two Bases, 3.55, and the Sum is 52.55 Feet, the whole superficial Content.

Demonstration. From the Rules delivered in the IVth and VIth Sections, the two foregoing Rules may easily be demonstrated.



Suppose a square Pyramid, ABV, to be cut by a Plane at *a* b, parallel to its Base AB, and it were required to find the Solidity of the Frustum, or Part *a* b AB. Let there be given

D=BA, the Side of the greater Base.
d=b *a*, the Side of the lesser Base.
H=CP, the perpendicular Height.

First, | 1 | $D-d : H :: d : \frac{dH}{D-d} = VC$ by the Figure.

Then | 2 | $DD \times \frac{H+VC}{3} =$ the whole Pyramid BVA, by Section the IVth.

And | 3 | $dd \times \frac{1}{3} VC =$ the Pyramid *a* V b cut off.

Q Then,

Then, in the 2d and 3d Steps, if, inftead of VC, you take $\frac{dH}{D-d}$ equal to it by the firft Step, it will be,

viz. 1. 2.	4	$\frac{DDDH}{3D-3d}$ = the whole Pyramid BVA;
and 1. 3.	5	$\frac{dddH}{3D-3d}$ = the Pyramid *a* V b.
4.—5	6	$\frac{DDDH-dddH}{3D-3d}$ = the Fruftum *a* b AB.

And by dividing DDD—ddd by D—d, and then multiplying the Quotient by $\frac{1}{3}$ H, the laft Step will be reduced to DD+Dd+dd : × $\frac{1}{3}$ H = the Fruftum *a* b A B; which, in Words, is thus:

To the Rectangle of the Sides of the two Bafes add the Sum of their Squares; that Sum being multiplied into One-third of the Fruftum's Height, will give its Solidity; which is the fame as the firft Rule of this Section.

See the Work of the Divifion.

$$
\begin{array}{l}
D-d)\ DDD-ddd\ (DD+Dd+dd \\
\quad\quad\ \ DDD-DDd \\
\quad\quad\ \ \overline{\quad\quad\quad\quad\quad\quad} \\
\quad\quad\quad\quad\quad DDd-ddd \\
\quad\quad\quad\quad\quad DDd-Ddd \\
\quad\quad\quad\quad\quad \overline{\quad\quad\quad\quad} \\
\quad\quad\quad\quad\quad\ \ Ddd-ddd \\
\quad\quad\quad\quad\quad\ \ Ddd-ddd \\
\quad\quad\quad\quad\quad\ \ \overline{\quad\quad\quad\quad} \\
\quad\quad\quad\quad\quad\quad\ 0\quad\ \ 0
\end{array}
$$

The ſame Reaſon will hold good for all Fruſtums of Pyramids or Cones, whether the Baſe be triangular or multangular, becauſe the Squares of the Sides of any Figure, or the Squares of the Diameters of Circles, are proportional to the Area; which proves the latter Part of the ſaid firſt Rule.

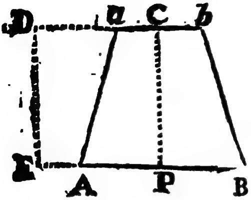
Again, to prove the ſecond Rule.

Suppoſe	1	$x=D-d$. And $F=$the Fruſtum.
then	2	$DD+Dd+dd=\frac{3F}{H}$ by the laſt.
1 ⊙ 2	3	$xx=DD-2Dd+dd$.
2 — 3	4	$3Dd=\frac{3F}{H}-xx$.
4 — 3	5	$Dd=\frac{F}{H}=\frac{1}{3}xx$. Or $Dd+\frac{1}{3}xx=\frac{F}{H}$
5 × H	6	$\overline{Dd+\frac{1}{3}xx}:\times H=F$, the Fruſtum *a* b A b.

Which, in Words, is thus:

To the Rectangle of the Sides of the two Baſes add one third Part of the Square of the Difference of the ſaid Sides, and multiply the Sum of the Height of the Fruſtum, the Product is the Solidity of the Fruſtum.

The ſuperficial Contents of Fruſtums (all but the Baſes) are compoſed of Trapeziums, ſo many as the Fruſtum has Sides. As the ſquare Fruſtum *a*bAB, in the laſt Figure is compoſed of four Trapeziums, having the two upper, and alſo the two lower Angles equal; if therefore the Trapezium *a*bAB be cut in two by the Line CP, and the two Pieces laid together, the Line bB upon the Line *a*A, the narrow End of the one to the broad End of the other, it will form a right-angled Parallelogram, as is plain by the Figure an-



nexed; the Parallelogram DCEP being equal to the Trapezium *ab*Ab; because the Side D*a* is equal to PB, and EA is equal to *a*C. Therefore, to find the Area of the Trapezium, add half the Side *ab* to half the Side AB, and it makes DC or EP; which multiplied by the Height PC, the Product is the Area of the Parallelogram DCEP, equal to the Trapezium *ab*AB; then, if that be multiplied by the Number of Trapeziums, the Product will be the superficial Content of the Frustum, wanting the Bases. Or, if the whole Perimeter of the greater Base, be added to the Perimeter of the lesser Base, and half the Sum multiplied by the Height, the Product will be the superficial Content of all the Trapeziums at once.

Note, That half the Sum of the Perimeters should be multiplied by the slant Height, up the Middle of one of the Trapeziums; but in the foregoing Examples I have multiplied by the perpendicular Height, because the Difference is very inconsiderable.

§ VIII. *Of the Frustum of a* CONE.

A Frustum of a Cone, is that Part which remains when the top End is cut off by a Plane parallel to the Base. To find the solid Content, the Rules are the same in Effect as for the Frustum of a Pyramid.

RULE I.

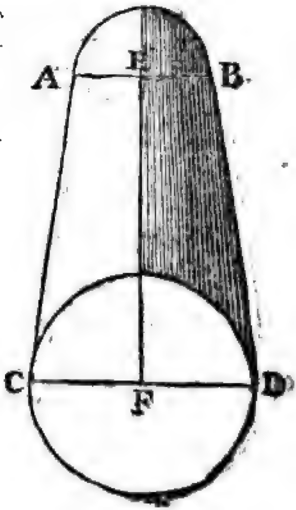
To the Rectangle of the Diameter of the two Bases add the Squares of the said Diameters, and multiply the

the Sum by .7854, the Product will be the Triple of a mean Area; which multiplied by $\frac{1}{3}$ of the perpendicular Height, that Product will be the solid Content.

Or thus: Multiply the Areas of the greater and lesser Bases together, and out of the Product extract the Square Root, and add the two Areas and Square Root together, and multiply the Sum by one-third of the perpendicular Height, the Product is the solid Content.

RULE II.

To the Rectangle of the greater and lesser Diameters, add one-third Part of the Square of the Difference, and multiply the Sum by .7854, the Product is a mean Area; which multiplied by the perpendicular Height, the Product is the Solidity.



Example. Let ABCD be the Frustum of a Cone, whose greater Diameter CD is 18 Inches, and the lesser Diameter AB 9 Inches, and the Length 14.25 Feet, the solid Content is required.

Multiply 18 by 9, and the Product is 162, and the Difference between 18 and 9 is 9, whose Square is 81; a third Part is 67, which add to 162, the Sum is 189; this multiplied by .7854, the Product is 148.44; which divided by 144, the Quotient is 1.03

Q 3 Feet;

Feet, the Area of a mean Base; which multiplied by 14.25 Feet, the Height, the Product is 14.6775 Feet, the solid Content.

Or thus, by the first Rule.

The Square of 18 (the greater Diameter) is 324, and the Square of 9 (the lesser Diamteer) is 81, and the Rectangle, or the Product of 18 by 9, is 162; the Sum of these three is 567, which multiplied by .7854, the Product is 445 3218; which divided by 144, the Quotient is 3.09 Feet, the triple Area of a mean Base; this multiplied by 4.75 Feet (a third Part of the Height), and the Product is 14.6775 Feet, the Solidity, the same as before.

See the Work.

	18	18 from	.7854
	8	9 subtr.	189
	———	—	————
	162	9 Rem.	70686
Add	27	9	62832
	———	—	7854
Sum	129	3)81 Square.	————
		—	144)148.4406(1.03
		27 a Third.	144
			———
Height		14.25 Feet.	444
Area Base		1.03 Feet.	432
		———	———
		4275	12
		14250	
		———	
Solid Content		14.6775 Feet.	

324 the Square of 18.
162 the Rectangle.
81 the Square of 9.

567 the triple Square of a mean Diameter.

```
       .7854
         567
      ------
       54978
      47124
     39270
    ---------
144)445.32(|18        (3.09
    -------            4.75
     1332             -----
     ----              1545
       36             2163
                     1236
                     -------
          The Solidity 14.6775
```

To find the superficial Content.

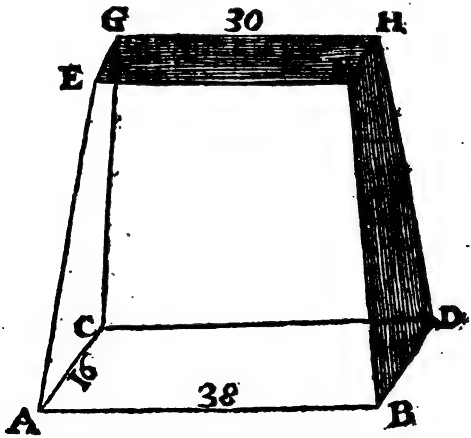
By Chap. I. Sect. IX. Problem 2. you will find the Circumference of the greater Base to be 56.5488, and of the lesser Base 28.2744; the Sum of both is 84.8232; the Half-sum is 42.4116; which multiplied by 14.25 Feet, and the Product is 604.36, &c. which divided by 12, the Quotient is 50.36 Feet, the curve Surface; to which add the Sum of the two Bases, 2.21 Feet, the Sum is 52.75 Feet, the whole superficial Content.

§ IX. *To measure the Frustum of a rectangled* Pyramid, *called a* PRISMOID, *whose Bases are parallel one to another, but disproportional.*

The RULE.

TO the greatest Length add half the lesser Length, and multiply the Sum by the Breadth of the greater Base, and reserve the Product.

Then, to the lesser Length, add half the greater Length, and multiply the Sum by the Breadth or the lesser Base, and add this Product to the other Product reserved, and multiply that Sum by a third Part of the Height, and the Product is the solid Content.



Example;

Example. Let ABCDEFGH be a Prifmoid given, the Length of the greater Bafe AB 38 Inches, and its Breadth AC 16 Inches; and the Length of the leffer Bafe EF is 30 Inches, and its Breadth 12 Inches, and the Height 6 Feet; the folid Content is required.

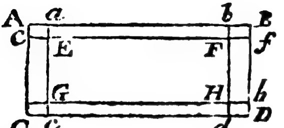
To the greater Length AB 38, add half EF the leffer Length 15, the Sum is 53; which multiplied by 16, the greater Breadth, and the Product is 848; which referve.

Again, to EF 30, add half AB 19, and the Sum is 49; which multiplied by 12 (the leffer Breadth EG), the Product is 588; to which add 848 (the referved Product), and the Sum is 1436; which multiplied by 2 (a third Part of the Height), and the Product is 2872; divide this Product by 144, and the Quotient is 19.94 Feet, the folid Content.

```
  38=AB            30=EF
  15=½EF           19=½AB
  ——               ——
  53               49
  16=AC            12=EG
  ——               ——
  318              588
  53
  ——
  848
  588
  ——
  1436
     2=a third Part of the Height
  ——
144)2872(19.94 Feet, the Content.
  ——
  1432
   1360
    640
  ——
    64
```

To

To prove this Rule. Let us ſuppoſe the Solid cut into Pieces, ſo as to make it capable of being meaſured by the foregoing Rules; thus: Let ABCD repreſent the greater Baſe, and EFGH the leſſer Baſe; and let the Solid be ſuppoſed to be cut thro' by the Lines, *ac*, *bd*, and *ef*, *gh*, from the Top to the Bottom; ſo will there be a Parallelopipedon, having its Baſes equal to the leſſer Baſe EFGH, and its Height 6 Feet, equal to the Height of the Solid: Multiply 30 (the Length of the Baſe by 12, the Breadth thereof), and the Product is 360; which multiplied by the Height 6 Feet, and the Product is 2160. Then there are two Wedge-like Pieces, whoſe Baſes are *ab*EF, and GH*cd*; if theſe two Pieces be laid together, the thick End of one to the thin End of the other, they will compoſe a rectangled Parallelopipedon; which to meaſure, multiply the Length of the Baſe 30 by its Breadth 2, and the Product is 60; which multiplied by 6 (the Height), the Product is 360. Then there are two other Wedge like Pieces, whoſe Baſes are *e* E *g* G, and *f* F H *h*; theſe two laid together will compoſe a rectangled Parallelopipedon: To meaſure this, multiply the Length of the Baſe 12 by the Breadth 4, the Product is 48; which multiplied by 6 (the Height), the Product is 288. And laſtly, there are four rectangled Pyramids, at each Corner one; which to meaſure, multiply the Length of one of the Baſes 4 by its Breadth 2, the Product is 8; which multiplied by 2 (a third Part of the Height) the Product is 16; and that multiplied by 4 (becauſe there are four of them), the Product is 64. Then add all theſe together, and the Sum is 2872, and divide by 144, the Quotient is 19.94 Feet, the ſame as before; which ſhews the Rule to be true.



See the Work.

12	30	12	4
30	2	4	2
360	60	48	8
6	6	6	2
2160	360	288	16
360			4
288			
64			64

144)2872(19.94 Feet, the whole Content.

1432
1360
640

64

To find the superficial Content.

Half the Perimeter of the greater Base is 54, and half the Perimeter of the lesser Base is 42, which added together, the Sum is 96; which multiplied by 6 (the Height), the Product is 576: Divide this Product by 12, the Quotient is 48 Feet; to which add the Sum of the two Bases 6.72 Feet, and the Sum is 54.72 Feet, the whole superficial Content.

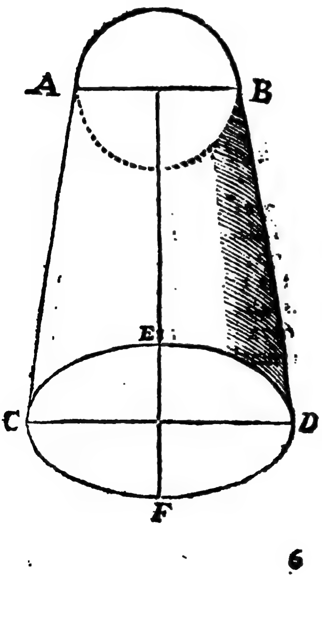
To

To measure a CYLINDROID; *that is, a Frustum of a* Cone, *having its Bases parallel to each other, but unlike.*

The RULE.

TO the longest Diameter of the greater Base, add half the longest Diameter of the lesser Base, and multiply the Sum by the shortest Diameter of the greater Base, and reserve the Product.

Then, to the longest Diameter of the lesser Base, add half the longest Diameter of the greater Base, and multiply the Sum by the shortest Diameter of the lesser Base, and add the Product of the former reserved Sum; and that Sum will be the triple Square of a mean Diameter; which multiplied by .7854, and that Product multiplied by a third Part of the Height, the Product is the solid Content.



Exam. Let ABCD be a Cylindroid, whose bottom Base is an Oval, the transverse Diameter being 44 Inches; and the conjugate Diameter 14 Inches; and the upper Base is a Circle, whose Diameter is 26 Inches; and the Height of the Frustum is 9 Feet; the Solidity is required.

To 44 (the greater Diameter of the lower Base) add 13 (half the

the Diameter of the greater Base, the Sum is 57; which multiplied by 14 (the conjugate Diameter of the greater Base, the Product is 798; which reserve. Then to 26 (the Diameter of the lesser Base) add 22 (half the traverse Diameter of the greater Base), and the Sum is 48; which multiplied by 26 (the Diameter of the lesser Base), the Product is 1248; to which add the former reserved Product, the Sum is 2046; which multiplied by .7854, the Product is 1606.9284; which multiplied by 3 (a third Part of the Height), the Product is 4820.7852; which divided by 144, the Quotient is 33.47 Feet, the solid Content. See the Work.

44=CD	26=AB
13=half AB	22=half CD
57 Sum.	48 Sum.
14=BF	26=AB
228	288
57	96
798 Product reserved.	1248
	798 add.
	2046
	.7854
	8184
	10230
	16368
	14322
	1606.9284
	3
	144)4820.78|52(33.47
	500
	687
	1118
	110

R This

This Rule being the same as that in the last Section, the Proof of that may serve as a sufficient Proof of this, if what has been before written be well considered.

To find the superficial Content.

To the Periphery of the Ellipsis 97.41, add the Periphery of the Circle 81.68, and the Sum is 179.09; the Half thereof 89.545, multiplied by 9, the Product is 805 905; which divided by 12, the Quotient is 67.16 Feet, the curve Surface: Then the Area of the Ellipsis is 3.36 Feet, and the Area of the Circle is 3.68 Feet; both which added to the curve Surface, the Sum is 74.2 Feet, the whole superficial Content.

§ XI. *Of a* Sphere *or* Globe.

A Sphere, or Globe, is a round solid Body, every Part of whose Surface is equally distant from a Point within it, called its Center; and it may be conceived to be formed by the Revolution of a Semicircle round its Diameter. To find its Solidity, this is

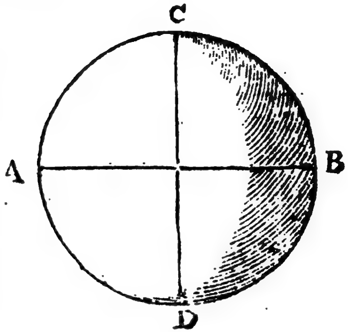
The RULE.

1. Multiply the Axis, or Diameter, into the Circumference, the Product is the superficial Content; which multiplied by a sixth Part of the Axis, the Product is the Solidity.

2. Or thus: As 21 is to 11, so is the Cube of the Axis to the solid Content.

3. Or, as 1 is to .5236, so is the Cube of the Axis to the solid Content.

ample. Let
D be a Globe
: Axis is 20
:s, then the
mf. will be
32 : Then,
e firſt Rule,
ply the Cir-
erence by the
, and the
uct will be
.64, which
e ſuperficial
entin Inches;



a ſixth Part thereof, which is 209 44, (becauſe
xact ſixth Part of 20 cannot be taken), multiply
ſixth Part by 20 (the Axis), and the Product is
.8, the Solidity in Inches. Or, if you multiply
uperficial Content by the Axis, and take a ſixth
of the Product, the Anſwer will be the ſame.

Or thus, by the ſecond Rule:

he Cube of the Axis is 8000; which multiplied
1, the Product is 88000; which divided by 21,
Quotient is 4190 47, the Solidity.

Or, by the third Rule:

f the Cube of the Axis be multiplied by .5236,
Product is 4188.8, the Solidity, the ſame as by
firſt Way. If you divide 4188.8 by 1728, the
otient is 2.424 Feet.

See the Work.

```
  62.832
      20
─────────
6)1256.640 the ſuperficial Content.
─────────
  209.44  a ſixth Part.
      20
  ──────
  4188.80 the Solidity in Inches.

      21 : 11 : : 8000
                    11
               ───────
              21)88000(4190.47 the Content.
               ───────
                  40
                  190
                    100
                     160
                     ───
                      13

      : .52 : 6 : : 8000
                    8000
          ──────────────
 1728)4188.8000(2.424 Feet, the Solidity.
      ───────
       7328
        4160
          7040
          ────
            128
```

Note, If the Axis of a Globe be 1, the Solidity will be .5236; and if the Circumference be 1, the Solidity will be .016887.

By

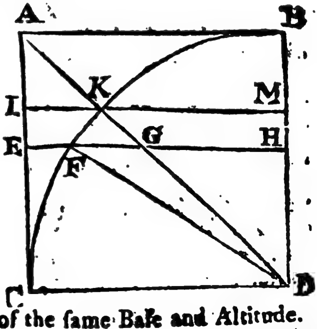
By Scale and Compasses.

Extend the Compasses from 1 to 20 (the Axis), that Extent (turned three times over from .5236), will at the last fall upon 4188.8, the solid Content in Inches: Or, extend the Compasses from 1728 to 8000 (the Cube of the Axis) that Extent will reach from .5236 to 2.424, the solid Content in Feet.

Extend the Compasses from 1 to 20 (the Axis), that Extent (turned twice over from 3 1416), will at last fall upon 1256.64, the superficial Content in Inches: Or, extend the Compasses from 144 to 400 (the Square of the Axis), that Extent will reach from 3.1416 to 8.72, the superficial Content in Feet.

Demonstration. Every Sphere is equal to a Cone, whose perpendicular Axis is the Radius of the Sphere, and its Base a Plane equal to all the Surface of it.

For you may conceive the Sphere to consist of an infinite Number of Cones, whose Bases, taken altogether, compose the Surface, and whose Vertexes meet altogether in the Center of the Sphere: Hence the Solidity of the Sphere will be gained, by multiplying its Surface by $\frac{1}{3}$ of its Radius.



Let the Square ABCD, the Quadrant CBD, and the right-angled Triangle ABD, be supposed all three to revolve round the Line BD as an Axis: Then will the Square generate a Cylinder, the Quadrant a Hemisphere, and the Triangle a Cone, all of the same Base and Altitude.

Then the Square of EH ($=\square$FD) $=\square$FH+ $\square$DH (but DH=GH). And ſince Circles are as the Squares of their Diameters (by *Euclid* 12. 2.) the Circle made by the Revolution of EH muſt be equal to both the Circles made by the Motions of FH and GH.

If you take the Circle made by the Revolution of FH from both, there will remain the Circle made by the Motion of GH, equal to the Ring deſcribed by the Motion of EF. And thus it will always be, where-ever you draw the Line EH or IM, &c.

Therefore the Aggregate, or Sum, of all the Rings made by the Revolution of the EF's, muſt be equal to that of all the Circles made by the Motion of the GH's; *i. e.* the Diſh-like Solid, formed by the revolving Rings, will be equal to the Cone, formed by the Revolution of the GH's, which are the Elements of the Triangle ABD; that is, the Diſh-like Solid will be as the Cone, $\frac{1}{3}$ of the circumſcribing Cylinder, and conſequently the Hemiſphere muſt be $\frac{2}{3}$ of it: Wherefore the Sphere is $\frac{2}{3}$ of the circumſcribing Cylinder.

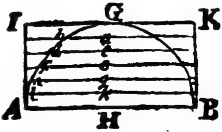
Let the Radius of the Sphere be r=CD, then the Diameter will be 2 r, let the Surface of the Sphere, generated by the revolving Semicircle, be called S, and that of the Cylinder, formed by the Revolution of 2 AC=2 r=Diameter, be called ſ. Wherefore in what was juſt now proved, the Expreſſion for the Solidity of the Sphere in this Notation will be $\frac{1\ rS}{3}$; and putting c equal to the Circumference of the Baſe, or for the Periphery of a great Circle of the Sphere, the curve Surface of the Cylinder will be 2 r c, alſo $\frac{rc}{2}$ will be the Area of a great Circle (by Sect. IX. of Chap. I. Prob. 1.) and this multiplied by 2r, makes rr c; which is the Solidity of the Cylinder, by Sect. V. of this Chapter. Now, ſince ſ was put equal to 2 r c= the

the Curve Surface of the Cylinder $\frac{fr}{2}$ (by fubfti-tuting f for $2\ r\ c$) will be alfo = the Solidity of the Cylinder. Now, fince the Sphere is = $\frac{2}{3}$ of the Cylinder, $\frac{rS}{3} = \frac{2 \times fr}{3 \times 2}$; that is, $\frac{rS}{3} = \frac{2fr}{6} = \frac{fr}{3}$. Wherefore $rS = rf$, that is, dividing by r, $S = f$; or the Surface of the Sphere is equal to the curve Surface of the Cylinder, but the curve Surface of the Cylinder was $2\ r\ c$.

Wherefore, to find the Area of the Surface of either Sphere or Cylinder, you muft multiply the Diameter ($= 2\ r$) by the Circumference of a great Circle of the Sphere, or by the Periphery of the Bafe. From this Notation alfo $\frac{rc}{2}$, the Area of a great Circle of the Sphere is plainly $\frac{1}{4}$ of $2\ r\ c$, the Surface of the Sphere; that is, the Surface of the Square is Quadruple of the Area of the greateft Circle of it.

Wherefore, to $2\ r\ c$, the convex Surface of the Cylinder, add $r\ c$, equal to the Area of both its Bafes, you will have $3\ r\ c$; which fhews you, that the Surface of the Cylinder (including its Cafes) is to the Surface of the Sphere as 3 to 2; or that the Sphere is $\frac{2}{3}$ of the circumfcribing Cylinder, in Area as well as Solidity.

Or you may prove the Sphere to be $\frac{2}{3}$ of the Cylinder of the fame Bafe and Altitude, by Lemma VI. aforegoing, thus:



Let AGB reprefent the Hemifphere, and AIKB half the Cylinder; then, if the Semidiameter GH be divided into fix equal Parts, and Lines drawn parallel to AB, the Diameter, the Squares of the Semichords, ab, cd, ef, &c. will be

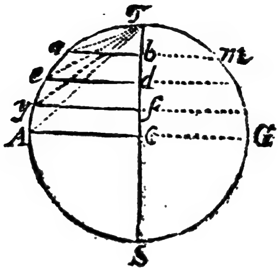
be a Series of Numbers, whoſe greateſt Term AH is a ſquare Number, the other differing by odd Numbers; that is, A H is 36, k l 35, g h 32, e f 27, cd 20, a b 11: But an infinite Series of ſuch Numbers are in Proportion to the infinite Number of Terms equal to the greateſt as 2 to 3. And becauſe the Hemiſphere is compoſed of an infinite Number of Circles, whoſe Diameters are the Chords of the Semicircle; and the Half-cylinder is compoſed of an infinite Number of Circles, whoſe Diameters are all equal to the Diameter of the Semicircles AB; therefore the Hemiſphere is in Proportion to the Half-cylinder as 2 to 3; and conſequently the whole Sphere bears the ſame Proportion to the whole Cylinder.

That the Superficies of every Sphere (or Globe) is equal to four times the Area of its greateſt Circle, is thus proved:

The Solidity of the Sphere is conſtituted of an infinite Number of parallel Circles (as is aforeſaid); conſequently the Superficies of the Sphere will be compoſed of the Peripheries of thoſe Circles which conſtitute its Solidity.

Note, In the following Demonſtration, ⊙ ſignifies any Circle in general; and if any two Letters be joined to it, thus, ⊙ A B, *&c.* then it denotes the Area of ſuch a Circle as thoſe two Letters repreſent the Radius of.

Let



Let D = TS, the Axis of any Sphere; then, according to the Property of a Circle, it

will be	1	$D - Tb \times Tb = \square ab$;
that is,	2	$D \times Tb - \square Tb = \square ab$;
therefore	3	$D \times Tb = \square aT$.
For	4	$\square AB + \square Tb = \square aT$ (*Eucl.* 1. 47.)
and	5	$D \times DT = \square eT$.
	6	$D \times Tf = \square yT$.

Hence it is evident, that the Series $\square aT$, $\square eT$, $\square yT$, &c. are in the ſame Ratio with Tb, Td, Tf, &c. viz. in arithmetical Progreſſion: Whence it follows, that the $\odot aT =$ to the Sum of all the Circles Peripheries between T and b.

And $\odot eT =$ the Sum of all the Circles Peripheries between T and d, &c.

Conſequently, that the $\odot AT =$ the Sum of all the Circles Peripheries, included between T and C; that is, $\odot AT =$ the Superficies of the Hemiſphere.

And becauſe $\square AC + \square TC = \square AT$, and $\square AC$ is equal to $\square TC$; therefore $\odot AT = 2 \odot AC$, is the Superficies of the Hemiſphere.

Conſequently, 4 $\odot$ AC will be the Superficies of the whole Sphere. Which was to be proved.

Scholium.

Scholium.

From the Method here ufed in proving the whole Superficies, it will be eafy to find the curve Superficies of any Fruftum, or Part of a Sphere, that is cut off by a Right Line, or Plane; *viz.* fuch as the Fruftum aTm in the laft Scheme, whofe curve Superficies is ⊙aT, as above. Therefore (becaufe □ab + □Tb = aT) it will be ⊙ab + ⊙Tb = the curve Superficies of that Fruftum.

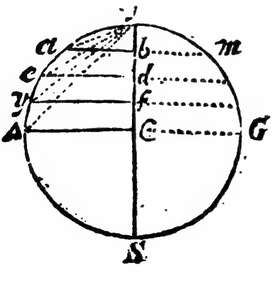
But if the Axis TS, and the Height Tb of the Fruftum, are given, then it will be TS × Tb = □aT, as in the third Step above; which gives the Proportion or Theorem following; *viz.*

As the Axis of the Sphere is to the whole Superficies of the Sphere; fo is the Height of any Fruftum to its curve Superficies.

To which if there be added the Area of the Fruftum's Bafe, the Sum will be the whole Superficies of the Fruftum.

That the Solidity of every Sphere is Two-thirds of its circumfcribing Cylinder, *may be thus proved.*

According to the Work above, it appears, that ⊙ab, ⊙ed, ⊙yf, &c. do conftitute the Solidity of the Sphere; and that □aT, □eT, □yT, &c. are a Series of Terms in arithmetical Progreffion, □AT being the greateft Term, and TC the Number of Terms; therefore ⊙AT × $\frac{1}{2}$ TC = the Sum of all the Series, by Lemma 2.



And becaufe □aT — □Tb = □ab. □aT — □Td = □ed. □yT — □Tf = □yf. □AT — □TC = □AC, &c. wherein

wherein □Tb, □Td, □Tf, &c. are a Series of Squares, whofe Roots Tb, Td, Tf, are in arithmetical Progreffion; □TC being the greateft Term, and TC the Number of Terms; therefore ⊙ TC × $\frac{1}{3}$ TC = the Sum of all the Series, by Lemma III.

Confequently, ⊙ AT × $\frac{1}{2}$ TC — ⊙ TC × $\frac{1}{3}$ TC = the Sum of all the Series ⊙ ab, ⊙ ed, ⊙ yf, &c. which conftitute the Solidity of the Half-fphere ATG. Put D=2TC, the Axis of the Sphere; then $\frac{1}{3}$ D = $\frac{1}{2}$TC, and $\frac{1}{6}$ P = $\frac{1}{3}$ TC. And becaufe □ AT = 2 □ TC, therefore ⊙ AT = 2 ⊙ TC = 1.5708 DD; and 1.5708 DD × $\frac{1}{4}$D = 0.3927 DDD.

Again; ⊙ TC × $\frac{1}{3}$ TC = 0.7854 DD × $\frac{1}{6}$ D = .1309 DDD, then 0.3627 DDD — 0.1309 DDD = 0.2618 DDD, the Solidity of the Half-fphere.

Confequently, 0.2618 DDD × 2 = .5236 DDD will be the folid Content of the whole Sphere, which is equal to $\frac{2}{3}$ of the Cylinder; the Diameter of whofe Bafe and Height, is = D.

For 0.7854 DDD = the Solidity of the Cylinder, by Sect. V. But $\frac{2}{3}$ of 0.7854 DDD = 0.5236 DDD, as before.

Scholium.

From this Demonftration it will be eafy to deduce or raife Theorems for finding the folid Content of any Fruftum of a Sphere, as Tm in the laft Figure.

For we there fuppofe the Fruftum aTm to be conftituted of an infinite Series of Circles, which have the fame Ratio with all thofe Circles that conftitute the Half-fphere.

Therefore it follows, that ⊙ aT × $\frac{1}{2}$ TB; — ⊙ bT × $\frac{1}{3}$ Tb, will be the Sum of all the Circles intercepted between T and b; confequently it will be the Solidity of that Fruftum.

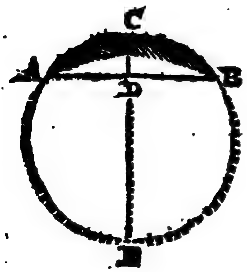
And, becaufe □ ab + □ Tb = aT; therefore ⊙ ab + ⊙ Tb × $\frac{1}{2}$ Tb : — ⊙ Tb × $\frac{1}{3}$ Tb = the Solidity. Let c = ab half the Diameter of the Fruftum's Bafe h = Tb its Height; and S = the Solidity of the Fruftum. Then ⊙ ab = 3.141600, and ⊙ Tb = 3.1416 hh; confequently,

sequently, $\frac{3.1416cch + 3.1416hhh}{2} - \frac{3.1416hhh}{3} = S.$ Which, being reduced, will become $3\,cch + hhh \times 0.5236 = S$; which is one Theorem for finding the Solidity of the Fruftum, and may be expreffed in Words, thus:

If to three times the Square of the Semidiameter of the Fruftum's Bafe, you add the Square of the Height of the Fruftum, and multiply the Sum by the Height of the Fruftum, and that Product multiplied by .5236, the Product will be the folid Content.

But if the Axis of the Sphere, and the Height of the Fruftum, be given; then put D=the Axis, h= the Height of the Fruftum, and c as before; it will be $D - h \times h = cc$, *viz.* $Dh - hh = cc$. Then will $3\,Dhh - 3hhh = 3cch + hhh$; confequently, $3\,Dhh - 2hhh \times 0.5236 = S$, the Fruftum's Solidity: Which is another Theorem for finding the Solidity of the Fruftum, and may be expreffed in Words, thus:

From three times the Axis fubtract twice the Height of the Fruftum, and multiply the Remainder by the Square of the Height, and that Product multiply by .5236, this laft Product will be the Solidity of the Fruftum.



Example. Let ABCD be the Fruftum of a Sphere: fuppofe AB (the Diameter of the Fruftum's Bafe) be 16 Inches, and C D (the Height) 4 Inches; the Solidity is required.

By

By the first Rule.

```
  8
  8
 ---
 64 Square of the Semidiameter AD.
  3
 ---
192
 16 add the Square of CD.
 ---
208
  4 multiply by CD.
 ---
832                    .5236
                         832
                       -----
                       10472
                      15708
                     41888
                    --------
                    435.6325
```

By the second Rule, thus:

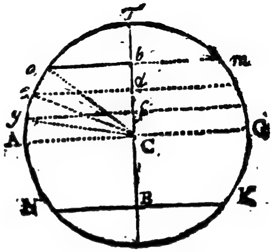
irst, by the Rule in Page 113, you will find the s of the whole Globe to be 20 Inches.

```
     20 Axis.              .5236
      3                      832
     ---                -------
m    60                    10472
tr.   8 twice CD.         15708
     ---                 41888
n.   52                 --------
lt.  16 Sq. of CD. . 435.6352 { the solid Content,
     ---                       { the same as before.
    312
     52
    ---
l. 832
```

S And,

And, if it be required to find the middle Part, amNK, uſually called the middle Zone of a Sphere.

Then, becauſe it is ſuppoſed that a m = NK, or (which is all one) that b C = CB; therefore it is plain, that if twice the Segment, a T m, be taken from the whole Sphere, there will remain the middle Zone a m N K.



But becauſe the Work is a little troubleſome, I will here ſhew how to raiſe a Theorem for the doing it:

Firſt, becauſe AC = yC = eC = aC = TC; therefore it will be □ A C — □ C f = y f, □ A C — □ C D = □ ed, □ A C — □ Cb = □ ab, &c.

Here becauſe □ A C, □ A C, □ A C, &c. are of Series of Equals, and C b the Number of all the Terms; therefore □ A C × C b = the Sum of all that Series (*per* Lemma I.)

And □ C f, □ C d, □ C b, &c. being a Series of Squares, whoſe Roots are in arithmetical Progreſſion, beginning at the Center, C; *viz.* o, C f, C d, C b, &c. wherein the greateſt Term is □ C b, and the Number of Terms is C b; therefore □ C b × $\frac{1}{3}$ C b = the Sum of all the Series (*per* Lemma III.)

Conſequently, the ⊙ A C × C b : — ⊙ C b × $\frac{1}{3}$ C b = the Sum of all the Series ⊙ y f, ⊙ e d, ⊙ a b, &c. which do conſtitute the Solidity of the half Zone a m A G.

And

And becaufe $\square AC - \square Cb = \square ab$; therefore $\odot AC - \odot ab = \odot Cb$. Confequently $\odot AC \times Cb :$

$$\frac{-\odot AC + \odot ab : \times Cb}{3} = 2 \odot AC + \odot ab : \times \tfrac{1}{3} Cb$$

will be the Solidity of the half Zone.

Put $D = AG = 2AC$, $x = am$, and $H = bB = 2Cb$.

Then $\odot AC = .7854 DD$, $\odot ab = .7854 xx$. And if we turn the common Factor .7854 into a Divifor 1.27323, and then take the triple of that Divifor; *viz.* 3.8197, the Refult of the precedent Work will produce the following Theorem.

Theo. $\left\{ \frac{2DD + xx}{3.8197} : \times H = \right\}$ the middle Zone amNK.

Which in Words is thus: To twice the Square of the Axis AG, and the Square of the Diameter of the Fruftum's Bafe (am), divide the Sum by 3.8197, then multiply the Quotient by the Height or Thicknefs of the middle Zone, and the Product will be the Solidity of the middle Zone required.

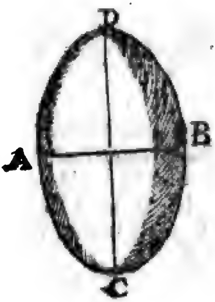
This is fo plain and eafy, that it needs no Example.

§ XII. *Of a* SPHEROID.

A Spheroid is a Solid reſembling an Egg. To find the ſolid Content thereof, this is

The RULE.

Multiply the Square of the Diameter of the greateſt Circle by the Length, and that Product multiply again by .5236; this laſt Product will be the Solidity of the Spheroid.

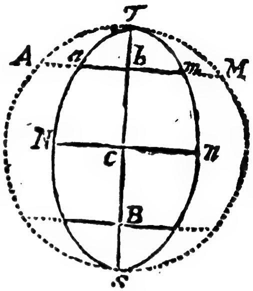


Let AB, the Diameter of the greateſt Circle, be 33 Inches, and CD (the Length) 55 Inches, the Solidity is required.

```
   33              59895
   33              .5236
 ----            -------
   99             359370
  99             179685
 ----           119790
 1089          299475
   55         ----------
 ----         31361.0220 the Solidity.
 5445
5445
 ----
59895
```

Demon-

Demonſtration. Every Spheroid is equal to $\frac{2}{3}$ of a Cylinder, whoſe Baſe is equal to the greateſt Circle of the Spheroid, and its Height equal to the Length of the Spheroid.



Suppoſe the Figure NTnSN, in the annexed Scheme, to repreſent a Spheroid, formed by the Rotation of the Semi-Ellipſis TNS, about its tranſverſe Axis TS.

Let D = T S, the Length of the Spheroid, and the Axis of the circumſcribing Sphere; and d = Nn, the Diameter of the greateſt Circle of the Spheroid:

Then, becauſe □ T C : □ N C : : □ A b : □ a b, by *Sect.* XV. *Step* 3. *Page* 125.

Therefore it will be, DD : dd : : □ Ab : □ ab.

But the Sum of an infinite Series of ſuch Circles as ⊙ Ab (whoſe Diameters are Chords) do conſtitute the Solidity of the Sphere. (By *Sect.* XI.)

And the Sum of an infinite Series of ſuch Circles as ⊙ a b (*viz.* whoſe Diameters are Ordinates of the Ellipſis) do conſtitute the Solidity of the Spheroid.

Therefore, D D : d d : : 0.5236 D D D : 0.5236 Ddd = the Solidity of the Spheroid. (*Eucl.* 5. 12.)

But 0.5236 Ddd = $\frac{2}{3}$ of the Cylinder, whoſe Diameter is = d, and Height = D. (By *Sect.* V.)

Now, from this Proportion, between the Sphere and its inſcribed Spheroid, it will be very eaſy to deduce Theorems for finding the ſolid Content, either of the Fruſtum or middle Zone of any Spheroid; having the ſame Height with that of the Sphere; for,

As the Solidity of the whole Sphere is to the Solidity of the whole Spheroid, ſo is any Part of the Sphere to the like Part of the Spheroid.

As for Inſtance: Suppoſe it was required to find the middle Zone of any Spheroid.

Let D=TS, and d=Nn, as above; and H=bB, x=AM, and c=am.

Then $\left\{\frac{2DD+xx}{3.8197}\times H\right.$ = the middle Zone of the Sphere. And 0.5236 DDD : 0.5236 ddD : : $\frac{2DD+xx}{3.8197}\times H : \frac{2ddH}{3.8197}+\frac{xxddH}{3.8197DD}$ = the middle Zone of the Spheroid.

Again, DD : dd : : xx : cc. Therefore $\frac{xxdd}{DD}$=cc. Conſequently, $\frac{xxdd}{DD}\times\frac{H}{3.8197}=\frac{cc}{3.8197}\times H$: Which being taken inſtead of $\frac{xxddH}{3.8197DD}$, there will ariſe the following Theorem $\left\{\frac{2dd+cc}{3.8197}\right.$: $\times$ H = the middle Zone of the Spheroid.

Note, That 3.8197=1.2732×3. See *Page* 102.

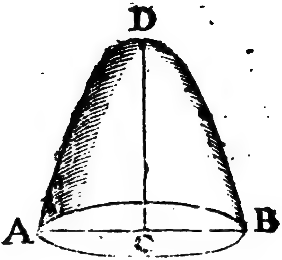
§ XIII. *Of a Parabolic* CONOID.

A Parabolic Conoid is ſomething like a half Spheroid, having its Sides ſomewhat ſtraiter. It is generated by ſuppoſing a Semi-parabola turned about its Axis. To find the ſolid Content thereof, this is

The RULE.

Multiply the Square of the Diameter of its Baſe by .7854, and multiply that Product by half the Height, that laſt Product ſhall be the ſolid Content.

Let ABCD be a Parabolic Conoid, the Diameter of whofe Bafe is 36 Inches, and its Height CD 33 Inches; the Solidity is required.



36	.7854	1017.8784
36	1296	33
216	47124	30536352
108	70686	30536352
1296	15708	2)33589.9872
	7854	16794.9936
	1017.8784	

1728)16794.99|36(9.71 Feet, the Content.

5552

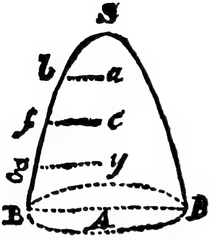
12249
12096

3339
1728

1611

Demonftration. The Parabolic Conoid is conftituted of an infinite Number of Circles, whofe Diameters are the Ordinates of the Parabola. Now, according to the Property of every Parabola, it will be, $SA : AB :: AB : \frac{\square AB}{SA} = L$, the *Latus Rectum*.

Then



$$\text{Then}\begin{cases} Sa \times L = \square\, ba, \\ Se \times L = \square\, fe, \\ Sy \times L = \square\, gy, \text{ \&c.} \end{cases}$$

Here $SA \times L$, $Se \times L$, $Sy \times L$, &c. are a Series of Terms in arithmet. Progreff. Therefore $\square\, ba$, $\square\, fe$, $\square\, gy$, &c. are alfo a Series of Terms in the fame Progreffion, beginning at the Point S, wherein $\square\, AB$ is the greateft Term, and S A, the Number of all the Terms. Therefore $\square\, AB \times \frac{1}{2} SA =$ the Sum of all the Series. (By Lemma II.)

Confequently, $\odot\, AB \times \frac{1}{2} SA =$ the Sum of all the Series of $\odot\, ba$, $\odot\, fe$, $\odot\, gy$, &c. which do conftitute the Solidity of the Conoid.

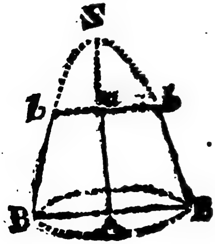
Put $D = 2AB$, and $H = SA$.

Then $.7854\, DD \times \frac{1}{2} H = .3927\, DDH$ will be the folid Content of the Conoid; which is juft half the Cylinder, whofe Bafe is $= D$, and Height $= H$.

This being rightly underftood, it will be eafy to raife a Theorem for finding the lower Fruftum of any Parabolic Conoid.

For, fuppofing $h = aA$, the Height of the Fruftum, and $p = Sa$, the Height of the Part b S b cut off, and $h + p = SA$, the Height of the whole Conoid.

Confequently, $\dfrac{\odot AB \times H + \odot AB \times p}{2} =$ the Solidity of the whole Conoid.



And $\dfrac{\odot ba \times p}{2} =$ the Solidity of the Part cut off.

Therefore

Therefore	1	$\frac{\odot AB \times h + \odot AB \times p - \odot ba \times p}{2}$ the Solidity of the Frustum.
But	2	$h+p : \square AB :: p : \square ba$
Conseq.	3	$h+p : \odot AB :: p : \odot ba$
$3 \because$	4	$\odot AB \times p : = \odot ba \times ph + \odot ba \times p$
$4 - \odot ba \times p$	5	$\odot AB \times p : = \odot ba \times h \odot ba \times h$
$\overline{}$ 1×2	6	$\odot AB \times h : + \odot AB \times p : - \odot ba \times p = 2F$.
$6 - 5$	7	$\odot AB \times h = 2F : - \odot ba \times h$.
$7 + \odot ba \times h$	8	$\odot AB \times h : + \odot ba \times h = 2F$.
$\overline{}$ $8 \div 2$	9	$\frac{\odot AB + \odot ba}{2} : \times h = F$, the Frustum's Solidity.

Let D = 2 AB, as before, and d = 2 ba, the Diameter of the Part cut off; then we shall have the following Theorem.

$0.3927\, DD + 0.3927\, dd : \times h =$ the Solidity of the Frustum required: Which in Words is thus:

Multiply the Sum of the Squares of the greater and lesser Diameters by .3927, and the Product by the Height of the Frustum, the last Product shall be the solid Content.

§ XIV. *Of a Parabolic* SPINDLE.

IF an acute Parabola be supposed to be moved about its greatest Ordinate, it will form a Solid, called a Parabolic Spindle. To find the solid Content, this is

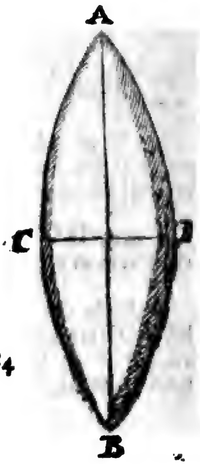
The

The RULE.

Multiply the Square of the Diameter of its greateft Circle by .41888 (being $\frac{8}{15}$ of .7854) and that Product by its Length; that laft Product is the folid Content.

Let ABCD be a Parabolic Spindle, whofe greateft Diameter C D is 36 Inches, and its Length A B 99 Inches; the Solidity is required.

```
 36=CD            .41888
 36                 1296
----             -------
 216              251328
108              376992
----             83776
1296 Square.    41888
                ---------
                542.86848
                       99
               ----------
                488581632
               488581632
               ----------
  1728)53743.97952(31.10184
                   ----
                   1903
                    1759
                     1179
                     14515
                       6912
                       ----
```

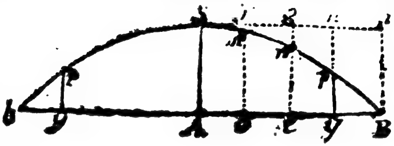


The folid Content is 31.10184 Feet.

Demonftration.

Demonftration. A Parabolic Spindle is conftituted of an infinite Series of Circles, whofe Diameters are all parallel to the Axis of the Parabola, as ⊙ m a, ⊙ n e, ⊙ p y, *&c.*

Let us fuppofe the Line S d parallel to A B, *&c.* Then it hath already been proved, that the Lines f m, gn, hp, *&c.* are a Series of Squares, whofe Roots are in arithmetical Progreffion, con-



fequently their Squares, *viz.* □ f m, □ g n, □ h p, *&c.* will be a Series of Biquadrates, whofe Roots will be in arithmetical Progreffion: Which being premifed, we may proceed thus:

First	1	$SA - fm = ma.$
	2	$SA - gn = ne.$
	3	$SA - hp = py.$
1 ⊙ 2	4	$\square SA - 2SA \times fm + \square fm = \square ma.$
2 ⊙ 2	5	$\square SA - 2SA \times gn + \square gn = \square ne.$
3 ⊙ 2	6	$\square SA - 2SA \times hp + \square hp = \square py,$ *&c.*

1. In thefe Equations, the □S A, □S A, □S A, being a Series of Equals, and A B the Number of all the Terms; therefore it will be $\square SA \times AB =$ the Sum of the Series. (By Lemma I.)

2. Becaufe f m, g n, h p, *&c.* are a Series of Squares, wherein S A is the greateft Term, and A B the Number of all the Terms.

Therefore $\frac{2SA \times SA \times AB}{3} = \frac{2\square SA \times AB}{3}$ will be the Sum of all the Series. (By Lemma III.)

3. And

3. And the $\square$fm, $\square$gn, $\square$hp, &c. will be a Series of Terms in the Ratio of Biquadrates, as above; $\square$SA being the greateſt Term, and AB the Number of all the Terms. Therefore it will be $\frac{\square SA \times AB}{5}$ = the Sum of all the Series. (By Lemma V.)

Whence it follows, that $\square SA \times AB - \frac{2\square SA \times AB}{3} + \frac{\square SA \times AB}{5} =$ the Sum of all the Series of $\square$ma, $\square$ne, $\square$py, &c.

That is, $\frac{8\square SA \times AB}{15} =$ the Sum of all the Series $\square$me, $\square$ne, $\square$py, &c. Conſequently, $\frac{8\odot SA \times AB}{15}$ = the Sum of all the Series of Circles, $\odot$ma, $\odot$ne, $\odot$py, &c. which conſtitute the Solidity of half the Spindle; *viz.* of SAB.

Therefore putting D = 2SA, and H = 2AB, it will be 0.41888 DDH = the Solidity of the whole Parabolic Spindle bSB, being $\frac{8}{15}$ of 0.7854 DDH, the Solidity of its circumſcribing Cylinder.

From hence we may alſo raiſe a Theorem for finding the Fruſtum, S A p y, of the laſt Figure.

For $\odot$ S A being the greateſt Term, $\odot$ p y the leaſt Term, and A y the Number of all the Terms or Circles included between A and y:

Therefore,

1 $\square SA \frac{2SA \times hp}{3} + \frac{\square hp}{5} : \times Ay =$ z the Sum of all the Series, $\square SA$, $\square$ ...a, $\square en$, $\square py$.

2 $3\square SA - 2SA \times hp + \frac{3\square hp}{5} : \times Ay = 3z$

3 $3\square SA - 2SA \times hp + \frac{3\square hp}{5} = \frac{3z}{Ay}$

4 $\square SA - 2SA \times hp = \square py - \square hp$, *per St.* 6.

5 $2\square SA + \frac{\square 3hp}{5} = \frac{3z}{Ay} - \square py + \square hp$.

6 $2\square SA + \square py - \frac{2}{5}\square hp = \frac{3z}{Ay}$

7 $2\odot SA + \odot py - \frac{2}{5}\odot hp : \times \frac{2}{3} Ay = z$

...um of all the Series of $\odot SA$, $\odot ma$, $\odot ne$, $\odot py$; ...do constitute the Solidity of the Frustum SApy. ...efore putting $D = 2SA$, as before, $C = 2py$, ...hp, and $H = Ay$; it will be $1.5708\,DD + ...CC - .31416xx : \times \frac{1}{3} H =$ the Frustum SApy. ...f we make $L = 2H$, then $1.5708\,DD + .7854 ... - .31416\,xx : \times \frac{1}{3} L =$ the Double of that Frustum being the middle Zone. Which in Words is

...tiply the Square of the greatest Diameter by ...8, and multiply the Square of the lesser Diameter by .7854, and multiply the Square of the Difference of the Diameters by .31416; from the Sum of the two former Products subtract the latter Product, and multiply the Remainder by one third Part of the ...h, and that Product will be the Solidity of the ...e Zone required.

CHAP. III.

Of the Measuring the Works of the several Artificers relating to Building; and what Methods and Customs are observed therein.

§ I. *Of* Carpenters *Work.*

THE Carpenters Works, which are measurable, are Flooring, Partitioning, and Roofing; all which are measured by the Square of 10 Feet long, and 10 Feet broad; so that one Square contains 100 Square Feet.

1. *Of Flooring.*

If a Floor be 57 Feet 3 Inches long, and 28 Feet 6 Inches broad; How many Squares of Flooring are there in that Room?

Multiply 57 Feet 3 Inches by 28 Feet 6 Inches, and the Product is 1631 Feet, *&c.* which divide by 100 (this is done by cutting from the Product two Figures towards the Right-hand, with a Dash of the Pen); and the remaining Figures are the Quotient,

and the Figures cut off are Feet: Thus, 1631 divided by 100, by cutting off 31 from the Right-hand thereof, the Quotient is 16 Squares, and the 31 cut off is 31 Feet.

See the Work both by Decimals, and alſo by Feet and Inches.

57.25		F.	I.	
28 5		57	3	
		28	6	
28625				
45800		456		
11450		114		
		28	7	6
16|31.625		7	0	0
		16|31	7	6

Facit 16 Squares and 31 Feet.

Note, That 5 is the Decimal for half of any thing, .25 is the Decimal for a Quarter, and .125 is the Decimal for half a Quarter; ſo in the laſt Example, .25 is the Decimal of 3 Inches, becauſe 3 Inches is a Quarter of a Foot; and 5 is the Decimal of 6 Inches, becauſe 6 Inches is half a Foot.

Example 2. Let a Floor be 53 Feet 6 Inches long, and 47 Feet 9 Inches broad; How many Squares are contained in that Floor?

47.75		F.	I.	
53.5		53	6	
		47	9	
23875				
14325		371		
23875		212		
		26	9	
25|54.625		13	4	6
		23	6	
		25|54	7	6

Facit 25 Squares and 54 Feet.

By

By Scale and Compaffes.

In the firft Example, extend the Compaffes from 1 to 28.5, that Extent will reach from 57.25 to 16 Squares and near a third Part.

In the fecond Example, extend the Compaffes from 1 to 47.5, that Extent will reach from 53.5 to 25 Squares and above a Half.

1. *Of Partitioning.*

Example 1. If a Partition between Rooms be in Length 82 Feet 6 Inches, and in Height 12 Feet 3 Inches; How many Squares are contained therein?

The Length and Breadth being multiplied together, the Product is 1010.625; which divided by 100 (as before is fhewed) and the Anfwer is 10 Squares 10 Feet; the Inches or Parts, in thefe Cafes, are of no Value.

12.25		F.	I.	
82.5		82	6	
		12	3	
6125				
2450		990	0	
9800		20	7	6
10|10.625		10|10	7	6

Facit 10 Squares 10 Feet.

Example 2. If a Partition between Rooms be in Length 91 Feet 9 Inches, and its Breadth 11 Feet 3 Inches; How many Squares are contained therein?

The Length and Breadth being multiplied together, the Product is 1032 Feet; which divided by 100, the Anfwer will be 10 Squares and 32 Feet.

91.75	F. I.
11.25	61 9
	11 3
45875	
18350	1009 3
9175	22 11 3
9175	
	10|32 2 3
10|32.1875	

3. *Of Roofing.*

It is a Rule amongst Workmen, that the Flat of any House, and half the Flat thereof, taken within the Walls, is equal to the Measure of the Roof of the same House; but this is when the Roof is true pitched: For if the Roof be more flat or steep than the true Pitch, it will measure to more or less accordingly.

Example 1. If a House within the Walls be 44 Feet 6 Inches long, and 18 Feet 3 Inches broad; How many Squares of Roofing will cover that House?

Multiply the Length and Breadth together, and the Product is 812 Feet, the Flat; the half thereof is 406 Feet; which added to the Flat, the Sum is 1218 Feet; which divided by 100, the Answer is 12 Squares and 18 Feet.

	18.25			F.	I.	
	44.5			44	6	
				18	3	
	9125					
	7300			352		
	7300			44		
				11	1	6
Flat	812.125			9	0	0
Half	406					
			The Flat	812	1	6
	12|18		The Half	406		
			Sum	12|18		

Facit 12 Squares 18 Feet.

By Scale and Compaſſes.

In the firſt Example of Partitioning, extend the Compaſſes from 1 to 12.25, that Extent will reach from 82.5 to 10 Squares and One Tenth.

In the ſecond Example, extend the Compaſſes from 1 to 11.25, that Extent will reach from 91.75 to 10 Squares, and a little leſs than a third Part.

In the Example of Roofing extend the Compaſſes from 1 to 18.25, that Extent will reach from 44.5 to 812, the Flat; to which add the Half thereof, and the Sum is 12.18; which is 12 Squares 18 Feet, as above.

There are other Works about a Building, done by the Carpenter, which are meaſured by the Foot, running Meaſure, that is, by the Number of Feet in Length only; as Cornices, Doors and Caſes, Window-frames, Guttering, Lintels, Sommers, Skirt-boards, *&c.*

Note 1. In the Meaſuring of Flooring, after you have meaſured the whole Floor, you muſt deduct out of it the Well-holes for the Stairs and Chimnies; and in Partitioning, for the Doors, Windows, *&c.* except (by Agreement) they are to be included.

Note

Note 2. In measuring of Roofing, seldom any Reductions are made for the Holes for the Chimney-shafts, the Vacancies for Lutheren-lights and Sky-lights; for they are more Trouble to the Workman than the Stuff which would cover them is worth.

§ II. *Of* BRICKLAYERS *Work.*

THE principal is Tiling, Walling, and Chimney-work.

1. *Of Tiling.*

Tiling is measured by the Square of 100 Feet, as Flooring, Partitioning, and Roofing were in the Carpenters Work; so that between the Roofing and Tileing, the Difference will not be much; yet the Tiling will be the most; for the Bricklayers sometimes will require to have double Measure for Hips and Vallies. When Gutters are allowed double Measure, the Way is to measure the Length along the Ridge-tile, and by that means the Measure of the Gutters becomes double; it is usual also to allow double Measure at the Eaves, so much as the Projector is over the Plate, which is commonly about 18 or 20 Inches.

Example 1. There is a Roof covered with Tiles, whose Depth on both Sides (with the usual Allowance at the Eaves) is 37 Feet 3 Inches, and the Length 45 Feet; I demand how many Squares of Tiling are contained therein?

F.	I.		
37	3		37.25
45	0		45
185			18625
148			14900
11	3		16|762.5
16|76	3		

Answer, 16 Squares 76 Feet.

Example 2. There is a Roof covered with Tiles, whose Depth on both Sides (with the Allowance at the Eaves) is 35 Feet 9 Inches, and the Length 43 Feet 6 Inches; I demand how many Squares of Tiling are in the Roof?

F.	I.		
43	6		37.75
35	9		43.5
215			17875
129			10725
21	9		14300
10	10	6	15|55.125
17	6		
15|55	1	6	

Here the Length and Depth being multiplied together, the Product is 1555 Feet; which divided by 100 (as before is taught) the Answer is 15 Squares and 55 Feet.

By Scale and Compasses.

In the first Example, extend the Compasses from 1 to 37.25, that Extent will reach from 45 to 16 Squares and a little above three Quarters of a Square.

In

In the second Example, extend the Compasses from 1 to 35.75, that Extent will reach from 43.5 to 15 Squares and 35 Feet; that is, a little above a Half-square.

2. *Of Walling.*

Bricklayers commonly measure their Work by the Rod Square of 16 Feet and a half; so that one Rod in Length, and one in Breadth, contain 272.25 Square Feet; for 16.5, multiplied in itself, produces 272.25 Square Feet. But in some Places the Custom is to allow 18 Feet to the Rod; that is, 324 Square Feet. And in some Places the usual Way is, to measure by the Rod of 21 Feet long and 3 Feet high, that is, 63 Square Feet; and here they never regard the Thickness of the Wall, but the usual Way is to moderate the Price according to the Thickness.

When you measure a Piece of Brick-work, the first thing is to enquire by which of those Ways it must be measured; then, having multiplied the Length and Breadth in Feet together, divide the Product by the proper Divisor, either for Rods or Roods, and the Quotient is Square Rods, or Square Roods, accordingly.

But commonly Brick-walls, that are measured by the Rod, are to be reduced to a Standard-thickness; *viz.* of a Brick and a half thick (if it be not agreed on the contrary); and to reduce a Wall to Standard-thickness, this is

The RULE.

Multiply the Number of superficial Feet that are found to be contained in any Wall by the Number of Half bricks which that Wall is in Thickness; one third Part of that Product shall be the Content thereof in Feet, reduced to the Standard-thickness of one Brick and a half.

Example.

Example 1. If a Wall be 72 Feet 6 Inches long, and 19 Feet 3 Inches high, and 5 Bricks and a half thick; How many Rods of Brick-work are contained therein, when reduced to the Standard?

```
             19.25 Height.
              72.5 Length.
             -----
              9625
             3850
           13475
           --------
          1395.625
                11
      ------------
        3)15351.875
      ------------
272.25) 5117.291(18 Rods.
        --------
          239479
          ------
     68.06)21679(3 Quarters of a Rod.
           -----
           12.61
```

Answer, 18 Rods 3 Quarters 12 Feet.

F.	I.	
72	6	
19	3	
648		
72		
18	1	6
9	6	0
1395	11	

3)15345

272)5115(18 Rods.

2395

68)219(3 Quarters of a Rod.

15

Note, That 68.06 is one-fourth Part of 272.25.

Note also, That in reducing of Feet into Rods, they usually reject the odd Parts, and divide only by 272, as is done in the second Way of the last Example; so the Answer, by the second Way, is 18 Rods 3 Quarters and 15 Feet; more by about $2\frac{1}{2}$ Feet than by the first Way, where it is done decimally; a thing very insignificant.

Example

Example 2. If a Wall be 245 Feet 9 Inches long, 16 Feet 6 Inches high, and two Bricks and a half thick; I demand how many Rods of Brick-work are contained therein, when reduced to Standard-thickneſs?

245.75
16.5
———
122875
147450
24575
———
4054.875
5
———
3)20270
———
272)6756(24 Rods.
———
1516
———
68)228(3 Quarters of a Rod.
———
24

Anſwer, 24 Rods 3 Quarters 24 Feet.

F.	I.	
245	9	
16	6	
1470		
245		
122	10	6
12	0	0
4054	10	6 Anſwer in Feet.

Before

Before I shew how to work the two last Examples by Scale and Compasses, I will shew how to find proper Divisors to facilitate the Operation; because it would be too intricate and tedious to perform by Scale and Compasses, according to the Rule above taught.

To find proper Divisors.

Divide 3 (the Number of Half-bricks in $1\frac{1}{2}$), by the Number of Half-bricks in the Thickness, the Quotient will be a Divisor, which will give the Answer in Feet. But if you would have a Divisor to bring the Answer in Rods at once, then multiply 272.25 by the Divisor found for Feet, and the Product will be a Divisor, which will give the Answer in Rods.

Example. Let it be required to find a Divisor proper to reduce a Wall of three Bricks thick.

Divide 3 by 6 (the Half-bricks in the Thickness) and the Quotient is .5, which is a Divisor that will give the Answer in Feet. Then multiply 272.25 by .5, and the Product is 136.125, the Divisor, which will give the Answer in Rods; that is, as 136.125 is to the Length of the Wall, so is the Height to the Content in Rods. Or, as .5 is to the Length, so is the Height to the Content in Feet.

After the same Manner you may find Divisors for any other Thickness, which you will find to be as expressed in the following little Table.

The Thicknefs of the Wall.	Divifors for the Anfwer in Feet.	Divifors for bringing the Anfwer in Rods.
1 Brick thick	1.5	408.375
$1\frac{1}{2}$ Brick thick	1.	272.25
2 Bricks thick	.75	204.1875
$2\frac{1}{2}$ Bricks thick	.6	163.35
3 Bricks thick	.5	136.125
$3\frac{1}{2}$ Bricks thick	.4285	116.659
4 Bricks thick	.375	102.0937

Let the fecond Example, aforegoing, be wrought by Scale and Compaffes, where the Length is 245.75, the Height 16.5, and the Thicknefs $2\frac{1}{2}$ Bricks.

Extend the Compaffes from 163.35 (the tabular Number againft $2\frac{1}{2}$ Bricks), to 245.75; that Extent will reach from 16.5 to 24 Rods and 8 Tenths.

Again, if the Length be 75 Feet 6 Inches, and the Height 18 Feet 9 Inches, at $3\frac{1}{2}$ Bricks thick; How many Rods are contained therein?

Extend the Compaffes from 116.659 (the tabular Number) to 18.75, that Extent will reach from 75.5 to 12.13, that is, 12 Rods and a little above half a Quarter.

It will be very proper and commodious, for fuch as have frequent Occafion to meafure Brick-work, to have in the Line of Numbers little Brafs Center-pins at each of the Numbers in the third Column of the above little Table, with a Figure to denote the Thicknefs of the Wall.

If a Wall be 104 *Feet* 9 *Inches long, and* 17 *Feet* 3 *Inches high; How many Rods are contained therein?*

104.75	F. I.
17.25	104 2
	17 3
52375	
20950	728
73325	104
10475	26 2 3
	12 9 0
63)1806 9375(28	
126	1806 11 3

Answer, 28 Rods 42 Feet.

546
504

42

Note, That such as dig Cellars, do many times make them by the Floor, 16 Feet square, and a Foot deep, being a Floor of Earth; that is, 324 solid Feet.

3. *Of Chimnies.*

If you are to measure a Chimney standing alone by itself, without any Party-wall being adjoined, then girt it about for the Length, and the Height of the Story is the Breadth; the Thickness must be the same as the Jambs are of, provided that the Chimney be wrought upright from the Mantle-tree to the Cieling, not deducting any thing for the Vacancy between the Floor (or Hearth) and the Mantle-tree, because of the Gatherings of the Breast and Wings, to make room for the Hearth in the next Story.

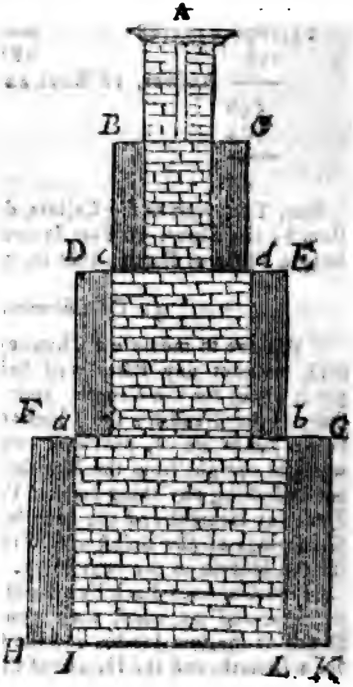
If the Chimney-back be a Party-wall, and the Wall be measured by itself, then you must measure the Depth of the two Jambs, and the Length of the Breast for a Length, and the Height of the Story the Breadth, at the same Thickness your Jambs were of.

When you measure Chimney-shafts, girt them with a Line round about the least Place of them, for the

the Length, and the Height shall be your Breadth; And if they be four Inch-work, then you must set down their Thickness at one Brick-work; but if they be wrought 9 Inches thick (as sometimes they are, when they stand high and alone above the Roof), then you must account your Thickness $1\frac{1}{2}$ Brick, in Consideration of Widths and Pargetting, and Trouble in Scaffolding.

It is customary, in most Places, to allow double Measure for Chimnies.

Example. Suppose this Figure, ABCDEFGHIK, to be a Chimney that hath a double Tunnel towards the Top, and a double Shaft, and is to be measured according to double Measure.



First, I begin with the Breast-wall IL, and the two Angles LK and HI, which together are 18 Feet 9 Inches; then take the Height of the Square HF, 12 Feet 6 Inches; which multiplied together, produce 234 Feet 4 Inches 6 Parts, for the Content of the Figure FGHK.

For

For the Square DaEB, the Length of the Breast-wall and two Angles, is 14 Feet 6 Inches, and the Height Da 9 Feet; which multiplied together, make 130 Feet 6 Inches, for the Content of the Part DaEb.

Then the Height of the next Square 7 Feet, and the Length of the Breast-wall and two Angles is 10 Feet 3 Inches; which multiplied together, produceth 71 Feet 9 Inches, for the Content of the Square BcCd.

The Compass of the Chimney-shafts is 13 Feet 9 Inches, and the Height 6 Feet 6 Inches; which multiplied together, make 89 Feet 4 Inches 6 Parts, the Content of the Shafts.

The Depth of the middle Fetter, that parts the Funnels, is 12 Feet, and its Wideness 1 Foot 3 Inches; which multiplied together, make 15 Feet, the Content thereof.

The Work.

	F.	I.			
	18	9			18.75
	12	6			12.5
	225	0			9375
	9	4	6		3750
					1875
FGHK	234	4	6	FGHK	234.375
	F.	I.			
	14	6			14.5
	9	0			9
DaEb	130	6		DaEb	130.5
	F.	I.			
	10	3			10.25
	7	0			7
BcCd	71	9		BcCd	71.75

F.	I.	
13	9	
6	6	
82	6	
6	10	6
The Shaft 89	4	6

13.75
6.5
6875
8250
The Shaft 89.375

	F.	I.
	1	3
	12	0
The Fetter	15	0

1.25
12
The Fetter 15.00

272)1082(3 Rods.

. 68) 266(3 Quarters.

Rem. 62 Feet.

	F.	I.	P.
FGHK	234	4	6
DaEb	130	6	0
BcCd	71	9	0
The Shaft	89	4	6
The Fetter	15	0	0
The Sum	541	0	0
The Double	1082	0	0

Having added the five Products together, and doubled the Sum, that double Sum is the Content of the Chimney in Feet, according to double or customary Measure; which Feet must be reduced to Rods, as was shewed before.

So the Feet in the foregoing Example being reduced to Rods (the Thickness being supposed 1½ Brick) it makes 3 Rods 3 Quarters and 62 Feet; that is, 4 Rods wanting 6 Feet.

This is all the Measure that can be allowed, when the Chimney stands in a Gavel or Side-wall; in which Case the Back of the Chimney (here not measured) is accounted as Part of the Gavel; but if the Chimnies stand by themselves, as all Stacks of Chimnies

in great Buildings do, in such Case, it is all Chimney-work, and therefore ought to be measured double on all Sides.

§ III. Of PLASTERERS Work.

THE Plasterers Works are principally of two Kinds; namely, 1. Works lathed or plastered, which they call Cieling. 2. Works rendered; which are of two Kinds; *viz.* upon Brick-walls, or between Quarters, in the Partitions between Rooms: All which are measured by the Yard square, or Square, of 3 Feet, which is 9 Feet.

1. *Of Cieling.*

If a Cieling be 59 Feet 9 Inches long, and 24 Feet 6 Inches broad; How many Yards doth that Cieling contain?

Multiply 59 Feet 9 Inches by 24 Feet 6 Inches, and the Product is 1463 Feet 10 Inches 6 Parts; which divided by 9, the Quotient is 162 Yards 5 Feet.

F.	I.			
59	9			59.75
24	6			24.5
236				29875
118				23900
29	10	6		11950
18	0	0		9)1463.875
1463	10	6	Answer	162.65

By

By Scale and Compaſſes.

Extend the Compaſſes from 9 to 59 Feet 9 Inches that Extent will reach from 24 Feet 6 Inches to 16.25 Yards.

2. *Of Rendering.*

Example. If the Partitions between Rooms be 141 Feet 6 Inches about, and 11 Feet 3 Inches high; How many Yards are in thoſe Partitions?

Multiply 141 Feet 6 Inches by 11 Feet 3 Inches, and the Product is 1591 Feet 10 Inches 6 Parts; which divided by 9, gives 176 Yards 7 Feet, the Anſwer.

	F.	I.	
	141	6	
	11	3	
	1556	6	
	35	4	6
	9)1591	10	6
Anſwer	176	7	

141.5
11.25
7075
2830
1415
1415
9)1591.875
176.87

Anſwer, 176.87 Yards.

Extend the Compaſſes from 9 to 141.5, that Extent will reach from 11.25 to 176.87 Yards.

Note 1. If there be any Doors, Windows, or the like, in your Partitioning, you muſt make Deductions for them.

Note 2. When you meaſure Rendering upon Brick-walls, you are to make no Deductions; but when you meaſure Rendering between Quarters, you may very well deduct one fifth Part for the Quarters, Braces, and Interſtices.

Note

Note 3. That Whiting and Colouring are both measured by the Yard, as Cieling and Rendering were; and as in Rendering between Quarters, you deduct one fifth Part, so in Whiting and Colouring you must add one fourth or one fifth Part at least.

§ IV. *Of* JOYNERS *Work*.

JOYNERS measure their Work by the Yard-square; but in taking their Dimensions, they differ from some others; for they have a Custom, and say, *We ought to measure where our Plane touches*: Wherefore in taking the Height of any Room, where there is a Cornice about, and swelling Panels and Mouldings, they, with a String, begin at the Top, and girt over all the Mouldings; which will make the Room to measure much higher than it is: Then for measuring about the Room, they only take it as it is upon the Floor.

Example 1. If a Room or Wainscot (being girt downwards over the Mouldings) be 15 Feet 9 Inches high, and 126 Feet and 3 Inches in Compass; How many Yards doth that Room contain?

Multiply the Compass by the Height, and the Product is 1988 Feet 5 Inches 3 Parts; which divided by 9, gives 220 Yards and 8 Feet, the Answer.

F.	I.			Decimal
126	3			126.25
15	9			15.75
620				63125
126				88375
63	1	6		63125
31	6	9		12625
3	9	0		
9)1988	5	3		9)1988.4375
Anſwer, 220	8			220.8

Facit 220 Yards 8 Feet.

Example 2. If a Room of Wainſcot be 16 Feet 3 Inches high (being girt over the Mouldings), and the Compaſs of the Room 137 Feet 6 Inches; How many Yards are contained therein?

Multiply 137 Feet 6 Inches by 16 Feet 3 Inches, and the Product is 2234 Feet 4 Inches 6 Parts; which divided by 9, the Quotient is 248 Yards and 2 Feet.

F.	I.		Decimal
137	6		137.5
16	3		16.25
830			6875
137			2750
34	4	6	8250
			1375
9)2234	4	6	9)2234.375
248	2	0	248.2

Facit 248 Yards 2 Feet.

By

By Scale and Compasses.

For the first Example, extend the Compasses from 9 to 126.25, that Extent will reach from 15.75 to 220.9 Yards.

For the second Example, extend the Compasses from 9 to 137.5, that Extent will reach from 16.25 to 248 Yards and above a Quarter.

In Joyners Work there is another thing to be observed; that is, in the measuring of Doors, Window-shutters, and all such Work as is wrought on both Sides, they are paid for Work and Half-work; so that in measuring all such Work, you must first find the Content, as before, and take half that Content, and add to it; so shall the Sum be the Content at Work and half.

Example. If the Window-shutters about a Room be 69 Feet 9 Inches broad, and 6 Feet 3 Inches high; How many Yards are contained therein at Work and half?

Multiply 69 Feet 9 Inches by 6 Feet 3 Inches, and the Product is 435 Feet 11 Inches 3 Parts; the Half whereof is 217 Feet 11 Inches 7 Parts; which added together, the Sum is 653 Feet 10 Inches 10 Parts; which divided by 9, the Quotient is 72 Yards 5 Feet, the Content at Work and half.

F.	I.		
69	9		69.75
6	3		6.25
418	6		34875
17	5	3	13950
			41850
435	11	3	435.9375
217	11	7	217.9687
9)653	10	10	653.9062
27	5		

Facit 248 Yards 5 Feet.

By

By Scale and Compasses.

Extend the Compasses from 9 to 69.75, that Extent will reach from 6.25 to 48.4 Yards; the Half whereof is 24.02; which added together, make 72.6 Yards, the Content at Work and half.

Note, That you must make Deductions for all Window-lights; but you must measure the Window-boards, Sopheta-boards, and Cheeks, by themselves.

§ V. *Of* Painters *Work*.

THE taking the Dimensions of Painters Work is the same as that of Joyners, by girting over the Mouldings and swelling Panels, in taking the Height; and it is but Reason that they should be paid for that on which their Time and Colour are both expended. The Dimensions thus taken, the casting up, and reducing Feet into Yards, is altogether the same as the Joyners Work; but the Painter never requires Work and half, but reckons his Work once, twice, or thrice coloured over. Only take Notice, that Window-lights, Window-bars, Casements, and such-like Things, they do at so much *per* Piece.

Example. If a Room be painted, whose Height (being girt over the Mouldings) is 16 Feet 6 Inches, and the Compass of the Room 97 Feet 9 Inches; How many Yards are in that Room?

Multiply 97 Feet 9 Inches by 16 Feet 6 Inches, and the Product is 1612 Feet 0 Inches 6 Parts; which being divided by 9, the Quotient is 179 Yards and 1 Foot.

F. I.

F.	I.		
97	9		97.75
16	6		16.5
584			48875
98			58650
48	10	6	9775
9)1612	10	6	9)1612.875(179
179	1		

Facit 179 Yards 1 Foot.

By Scale and Compasses.

Extend the Compasses from 9 to 16.5, that Extent will reach from 97.75 to 179.2 Yards.

§ IV. *Of* GLASIERS *Work.*

GLASIERS measure their Work by the Foot square; so that the Length and Breadth of a Pane of Glass in Feet, being multiplied into each other, produceth the Content.

Note, That Glasiers usually take their Dimensions to a Quarter of an Inch; and in multiplying Feet, Inches, and Parts, the Inch is divided into 12 Parts, as the Foot is, and each Part subdivided into 12, *&c.*

Example. If a Pane of Glass be 4 Feet 8 Inches and 3 Quarters long, and 1 Foot 4 Inches 1 Quarter broad; How many Feet of Glass are in that Pane?

The Decimal of $\left\{\begin{array}{l}8 \text{ Inches } \frac{3}{4} \\ 4 \text{ Inches } \frac{1}{4}\end{array}\right\}$ is $\left\{\begin{array}{l}.728 \\ .354\end{array}\right.$

F.	I.	P.			4.729
4	8	9			1.354
1	4	4			
4	8	9			18916
1	6	11	0		23645
	1	2	2	3	14187
					4729
6	4	10	2	3	6.403066

Anſwer, 6 Feet 4 Inches.

By Scale and Compaſſes.

Extend the Compaſſes from 1 to 1.345, that Extent will reach from 4.729 to 6.4 Feet, the Content.

Example 2. If there be 8 Panes of Glaſs, each 4 Feet 7 Inches 3 Quarters long, and 1 Foot 5 Inches 1 Quarter broad; How many Feet of Glaſs are contained in the ſaid 8 Panes?

The Decimal of $\left\{ \begin{array}{l} 7 \text{ Inches } \frac{3}{4} \\ 5 \text{ Inches } \frac{1}{4} \end{array} \right\}$ is $\left\{ \begin{array}{l} .646 \\ .437 \end{array} \right.$

F.	I.	P.			4.646
4	7	9			1.437
1	5	3			
					32522
4	7	9			13938
1	11	2	9		18584
	1	1	11	3	4646
6	8	1	8	3	6.676302
				8	8
53	5	1	6	0	53.410416

Facit 53 Feet 5 Inches.

By

By Scale and Compasses.

Extend the Compasses from 1 to 1.437, that Extent will reach from 4.646 to 6.676; then extend the Compasses from 1 to 8, that Extent will reach from 6.676 to 53.4, the Content.

Example 3. If there be 16 Panes of Glass, each 4 Feet 5 Inches and a half long, and 1 Foot 4 Inches 3 Quarters broad; How many Feet of Glass are contained therein?

F.	I.	P.				
4	5	6				4.458
1	4	9				1.395
						22290
4	5	6				40122
1	5	10	0			13374
	3	4	1	6		4458
6	2	8	1	6		6.218910
				4		4
24	10	8	6	0		24.875640
				4		4
96	6	10	0	0		99.502560

Facit 99 Feet 6 Inches.

Note, That instead of multiplying by 16, I have multiplied by 4 twice, because 4 times 4 is 16.

By Scale and Compasses.

Extend the Compasses from 1 to 1.395, that Extent will reach from 4.458 to 6.219; then extend the Compasses from 1 to 16, that Extent will reach from 6.219 to 99.5 Feet, the Content.

Note, That when Windows have Half-rounds at the Top, they measure them at the full Height, as if they were square. Also round or oval Windows are mea-

sured at the full Length and Breadth of their Diameters. Likewise Crotchet-windows in Stone-work are all measured by their full Squares. And there is Reason for so doing; for the Trouble in taking their Dimensions to work by, the Waste of Glass in working, and the Time expended in setting up, is far more than the Glass can be valued at.

§ V. *Of* MASONS *Work.*

MASONS measure their Work sometimes by the Foot solid, sometimes by the Foot superficial, and in some Places they measure their Walling by the Rood, that is, 21 Feet long and 3 Feet high, which is 63 square Feet. Examples of each are as follow.

Example. If a Wall be 97 Feet 5 Inches long, 18 Feet 3 Inches high, and 2 Feet 3 Inches thick; How many solid Feet are contained in that Wall?

F.	I.			
97	5			97.417
18	3			18.25
776				487085
97				194834
24	4	3		779336
6	0	0		97417
1	6	0		
1777	10	3		1777.86025
2	3			2.25
				888930125
3555	8	6		355572050
444	5	6	9	355572050
4000	2	0	9	4000.1855625

Multiply

Multiply the Length, Height, and Thickness together, and the last Product is 4000 Feet 2 Inches, the solid Feet contained in the Wall.

By Scale and Compasses.

Extend the Compasses from 1 to 18.25, that Extent will reach from 97.417 to 1777.86; then extend from 1 to 1777.86, that Extent will reach from 2.25 to 4000.18, the solid Content.

Example 2. If a Wall be 107 Feet 9 Inches long, and 20 Feet 6 Inches high; How many Feet superficial are contained therein?

F.	I.		
107	9		107.75
20	6		20.5
2155	0		53875
53	10	6	215500
2208	10	6	2208.875

Facit 2208 Feet 10 Inches.

By Scale and Compasses.

Extend the Compasses from 1 to 107.75, that Extent will reach from 20.6 to 2208.875, the superficial Feet.

Example 3. If a Wall be 112 Feet 3 Inches long, and 16 Feet 6 Inches high; How many Roods are contained therein?

F.	I.	
112	3	
16	6	
676	0	
112		
56	1	6
1852	1	6

```
      112.25
        16.5
      ------
       56125
      67350
     11225
   ----------
63)1852.125(29
   ------
     592
   -----
      52
```

Facit 29 Roods 25 Feet.

By Scale and Compasses.

Extend the Compasses from 63 to 16.5, that Extent will reach from 112.25 to 29.4 Roods, the Content.

CHAP.

CHAP. IV.

The Measuring of BOARD *and* TIMBER.

§ I. *Of* BOARD MEASURE.

TO measure a Board, is no other but to measure a long Square.

Example 1. If a Board be 16 Inches broad and 13 Feet long; How many Feet are contained therein?

Multiply 16 by 13, and the Product is 208; which divided by 12, gives 17 Feet, and 4 remains, which is a third Part of a Foot.

Or thus: Multiply 156 (the Length in Inches) by 16, and the Product is 2496; which divided by 144, the Quotient is 17 Feet, and 48 remains, which is a third Part of 144, the same as before.

12 : 13 :: 16
13

48
16

12)208

$17\frac{4}{12}$

Or, 144 : 156 :: 16
16

936
156

144)2496($17\frac{48}{144}$
1056

48

By Scale and Compaſſes.

Extend the Compaſſes from 12 to 13, that Extent will reach from 16 to $17\frac{1}{3}$ Feet, the Content.

Or, extend from 144 to 156 (the Length in Inches) that Extent will reach from 16 to $17\frac{1}{3}$ Feet, the Content.

Example 2. If a Board be 9 Inches broad; How many Inches in Length will make a Foot?

Divide 144 by 19, and the Quotient is 7.58 very near; and ſo many Inches in Length, if a Board be 19 Inches broad, will make a Foot.

Inch.		Inch.		Inch.		Inch.
19	:	144	::	1	:	7.58 *ferè.*

Extend

Extend the Compasses from 19 to 144, that Extent will reach from 1 to 7.58; that is, 7 Inches, and something more than a half. So, if a Board be 19 Inches broad, if you take 7 Inches, and a little more than a half with your Compasses from a Scale of Inches, and run that Extent along the Board, from End to End, you may find how many Feet that Board contains; or you may cut off from that Board any Number of Feet desired.

For this Purpose there is a Line upon most ordinary Joint-rules, with a little Table placed upon the End of all such Numbers as exceed the Length of the Rule, as in this little Table annexed.

0	0	0	0	5	0	8½	6
12	6	4	3	2	2	1	1
1	2	3	4	5	6	7	8

Here you see, if the Breadth be one Inch, the Length must be 12 Feet; if two Inches, the Length is 6 Feet; if five Inches broad, the Length is 2 Feet 5 Inches, *&c.*

The rest of the Lengths are expressed in the Line, thus: If the Breadth be 9 Inches, you will find it against 15 Inches, counted from the other End of the Rule; if the Breadth be 11 Inches, then a little above 13 Inches will be the Length of a Foot, *&c.*

§ II. *Of* Squared Timber.

BY Squared Timber are here meant such as have equal Bases, and the Sides strait and parallel. The Rules for measuring all such Solids are shewed in § II. of Chap. II. to which I refer.

Example

Example 1. If a Piece of Timber be 1 Foot 3 Inches (or 15 Inches) square) and 18 Feet long; How many solid Feet are contained therein?

```
        15
        15
       ---
        75
       15
      ----
       225
        18
      ----
      1800
      225
      ----
144)4050(28.125
      ----
      1170
      ----
      180
       360
        720
```

```
F.  I.
1   3
1   3
------
1   3
    3   9
----------
1   6 , 9
        6
----------
9   4   6
        3
----------
28  1   6
```

Answer, 28 Feet and half a Quarter.

Here, instead of multiplying by 18, where I wrought by Feet and Inches, I multiplied by 6, and then by 3, because 3 times 6 is 18.

Example 2. If a Piece of squared Timber be 2 Feet 9 Inches deep, 1 Foot 7 Inches broad, and 16 Feet 9 Inches long; How many Feet of Timber are in that Piece?

Multiply the Depth, Breadth, and Length together, and the Product will be the Content.

```
        33
        19
      ----
       297
       33
      ----
       627
     16.75
      ----
      3135
     4389
    3762
    627
    ------
144)10502.25(72.93
    ------
     422
     1342
      465
      ---
       93
```

```
F.  I.
2   9
1   7
-----
2   9
1   7   3
---------
4   4   3
16  8   0
---------
69  9   0
3   3   2   3
-------------
72  11  2   3
```

Answer, 72 Feet 11 Inches; or 72 Feet 93 Parts.

By Scale and Compasses.

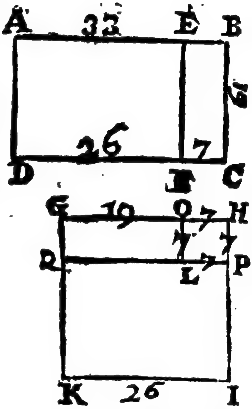
For the first Example, extend the Compasses from 12 to 15 Inches (the Side of the Square, that Extent will reach from 18 Feet (the Length being twice turned over) to 28 Feet, and something more.

For the second Example, find a mean Proportional between 19 Inches and 33 Inches, by dividing the Space between them into two equal Parts, and the Compass Point will rest upon 25, which is a mean Proportional between 19 and 33.

Then extend the Compasses from 12 to 25 (the Proportional found) that Extent will reach (being twice turned over) from 16.75 Feet, the Length, to 7293 Feet, the Content.

5 A com-

A common Error is committed, for want of Art, in measuring these last Sorts of Solids, by adding the Depth and Breadth together, and taking half for the Side of a mean Square. This Error, though it be but small, when the Depth and Breadth are pretty near equal; yet if the Difference be great, the Error is very considerable; for the Piece of Timber thus measured, will be more than the Truth, by a Piece whose Length is equal to the Length of the Piece of Timber to be measured, and the Square equal to half the Difference of the Breadth and Depth, as I shall here demonstrate.



I say, the Square GHIK is greater than the Parallelogram ABCD, by the little Square OHPL; for the Parallelogram QPIK is equal to the Parallelogram AEFD; and the Parallelogram GOLQ is equal to the Parallelogram EBCF. Therefore the Square is greater than the Parallelogram by the little Square OHPL; which was to be proved.

Otherwise, you may prove it by Numbers, thus: The Sum of 33 and 19 is 52, the half thereof is 26, the Square of 26 is 676, and the Product of the Depth and Breadth is 627: The Difference of these two is 49, equal to the Square of half the Difference; for the Difference between 33 and 19 is 44, the half thereof is 7, whose Square is 49; which was to be proved.

Now, if this 49 be multiplied by the Length of the Piece, and that Product divided by 144, to bring it to Feet, and those Feet added to the true Content, the

Sum

Sum will be equal to the Content found by the false Way mentioned.

See the Work of both.

33 Depth.	16.75 the Length.
19 Breadth.	49 the Sq. of ½ Diff.
52 Sum.	15075
	6700
26 half.	
26	144)820.75(5.69
156	1007
52	1435
676	139
16.75	
3380	
4732	
4056	
676	
144)11323.00(78.63	
1243	
910	
460	
28	

	Feet.	
To	72.93	the true Content.
Add	5.69	the Part superfluous.
Rem.	78.62	equal to the Content by the false Way.

By Feet and Inches.

F.	I.			
0	7			
0	7			
0	4	1		
16	9			
5	5	4		
	3	0	9	
5	8	4	9	Part superfluous.
72	11	2	3	True Content add.
78	7	7	0	equal to the Content by the false Way.

	F.	I.	
	2	2	
	2	2	
	4	4	
		4	4
	4	8	4
	16	9	
	75	1	4
	3	6	3
False C.	78	7	7

To find how much in Length makes a Foot of any squared Timber.

Always divide 1728 (the solid Inches in a Foot) by the Area of the Base; the Quotient is the Length of a Foot.

This Rule is general for all Timber, which is of equal Thickness from End to End, whether it be square, triangular, multangular, or round.

Example 1. If a Piece of Timber be 18 Inches square; How much in Length will make a Foot solid?

18
18
———
144
18
———
324)1728(5⅓ Inches; which is the Answer.
1620
———
108

By

By Scale and Compasses.

Extend the Compasses from 1 to 18, that Extent will reach from 18 to 323, the Square or Area of the Base; then extend from 324 to 1728, that Extent will reach down from 1 to 5 Inches, and $\frac{1}{3}$ of an Inch.

Or thus: Extend the Compasses from 18 to 41.569, that Extent, turned twice over from 1, will at last fall upon $5\frac{1}{3}$, as before.

Note, That 41.569 is the square Root of 1728.

Example 2. If a Piece of Timber be 22 Inches deep, and 15 Inches broad; How much in Length will make a Foot?

$$
\begin{array}{r}
22 \\
15 \\
\hline
110 \\
22 \\
\hline
330)1728(5.23 \\
\underline{} \\
780 \\
1200 \\
\hline
210
\end{array}
$$

Answer, 5 Inches and .23 Parts.

By Scale and Compasses.

Extend the Compasses from 1 to 15, that Extent will reach from 22 to 330; then extend from 330 to 1728, that Extent will reach from 1 to 5.23 Inches, the Length of a Foot.

There is a Line for this Purpoſe upon moſt ordinary Rules, with a little Table at the End of all ſuch Numbers as exceed the Length of the Rule, ſuch as this annexed.

0	0	0	0	9	0	11	3	9	Inches.
144	36	16	9	5	4	2	2	1	Feet.
1	2	3	4	5	6	7	8	9	Side of the Sq.

Here you ſee, if the Side of the Square be 1, the Length muſt be 144 Feet; if two Inches be the Side of the Square, it muſt be 36 Feet in Length, to make a ſolid Foot, *&c.*

If the Side of the Square be not in the little Table, you will find it upon the Line; thus, if the Side of the Square be 16 Inches, you will find it againſt 6 Inches and 7 Tenths, counted from the other End of the Rule.

Then if you take the Length of a Foot from the Line of Inches with your Compaſſes, and run the Compaſſes along the Piece from End to End, you will find how many Feet are contained in that Piece; or you may cut off any Number of ſolid Feet that ſhall be deſired; but if the Sides of the Piece be unequal, find a mean proportional Number, as is before taught, by dividing the Diſtance upon the Line of Numbers into two equal Parts: Thus, if the Breadth be 25 Inches and the Depth 9 Inches, divide the Space upon the Line of Numbers into two equal Parts, and you will find the middle Point at 15; ſo is 15 Inches the geometrical mean Proportional ſought; then if you look for 15 upon the Line above-mentioned, you will find 7 Inches and a little above half to be the Length of a Foot.

§ III.

§ III. *Of unequal Squared Timber.*

BY unequal Squared Timber, I mean all ſuch as have unequal Baſes; that is, ſuch as is thicker at one End than at the other; and ſuch are moſt Timber-trees when they are hewn, and brought to their Squares.

The uſual Way to meaſure ſuch Timber, is to take a Square about the Middle of the Piece, which they take to be a mean Square: This Way, when the Piece is pretty near as thick at one End as at the other, is ſomething near the Truth; but when there is a great Diſproportion between the Ends of the Piece, the Error is conſiderable. All ſuch Solids being the Fruſtums of Pyramids, the true Way of meaſuring them muſt be by Sect. VII. Chap. II. I ſhall give an Example or two, which I will work both by the true and falſe Ways, whereby you will ſee the Difference.

Example 1. If a Piece of Timber be 25 Inches ſquare at the greater End, and 9 Inches ſquare at the leſſer End, and 20 Feet long; How many Feet of Timber are in that Tree?

```
          25
           9
Sum       34
Half      17 the Side of the Square in the Middle.
          17
         119
          17
         289
          20
144)5780(40.13
       200
        560
        128
```

Anſwer, 40.13 Feet, by the falſe Way.

By Rule II. Sect. VII. Chap. II.

```
 25         25
  9          9
 ---        --
225         16 Difference of the Sides.
            16
            --
            96
           16
           ---
         3)256 the Square.
           ---
           85.333
          225
          -------
          310.333
               20
          -------
      144)6206.660(43.101
          ---------
           446
            146
             260
             ---
             116
```

Anfwer, 43.101 Feet, by the true Way; fo that there is near 3 Feet Difference.

By Scale and Compaffes.

Extend from 1 to 9, that Extent will reach from 25 (the fame Way) to 225, the Rectangle of the Sides of the two Bafes; then the Difference between the faid Sides is 15; extend from 3 to 16, that Extent will reach from 16 to 85.333, a third Part of the Square; which added to 225, the Sum is 310 333, a mean Area: Then extend from 144 to 310.333, that Extent

Extent will reach from 20 (the Length) to 43.1 Feet, the Content the true Way.

Extend the Compasses from 12 to 17 (the Side of the middle Square), that Extent will reach from 20 (the Length, being twice turned over), to 40 1 Feet, the Content by the false Way.

Example 2. If a Piece of Timber be 32 Inches broad and 20 Inches deep, at the greater End, and 10 Inches broad and 6 deep, at the lesser End, and 18 Feet long; How many Feet of Timber are in that Piece?

Rule I. Sect. VII. Chap. II.

```
  32             6
  20            10
 ----           --
 640            60
 ----
38400          (195.959 mean Proportional.
 1               640    the greater Base.
-----             60    the lesser Base.
29)284.         -------
 385)2300        895.959 the Sum.
 3969)37500           6 1/3 Height.
 39185)231900   -------
 391909)3597500 5375.754
             144)5375 754(37.33
                -------
                1055
                  477
                   455
                -------
                    23
```

Add

Add	32		20	add.
	10		6	
Sum	42		26	Sum.
Half	21		13	half.

```
   13
   --
   63
  21
 ---
 273 Area in the Middle.
  18 Length.
 ----
 2184
 273
 ----
144)4914(34.12
    ----
    594
     180
      360
     ----
      72
```

		Feet.
Anfwer.	Content the true Way————	37.33
	Content the falfe Way————	34.12

By Scale and Compaffes.

Extend the Compaffes from 1 to 20, that Extent will reach from 32 to 640, the Area of the greater Bafe.

Then extend from 1 to 10, that Extent will reach from 6 to 60, the Area of the leffer Bafe: Then extend from 1 to 60, that Extent will reach from 640 to 38400, the Product of the two Areas: Find the fquare Root thereof, by dividing the Space between 1 and 38400 into two equal Parts, fo you will find the middle Point at 195.959, the Root fought; which

is a mean Proportional between the greater and lesser Areas; then add the mean Proportional and two Areas together, and the Sum is 895.959; which multiplied by 6 (a third Part of the Length) by extending from 1 to 6, that Extent will reach from 895.959 to 5375.75. Then extend from 144 to 5375.75, and that Extent will reach from 1 to 37.33 Feet, the true Content.

For the false Way, half the Sum of the Breadths is 21, which is the Breadth in the Middle; and half the Sum of the Depths is 13: Extend from 1 to 13, that Extent will reach from 21 to 273, the Area of the middle Base: Then extend from 144 to 273, that Extent will reach from 18, the Length, to 34.12, the Content the false Way.

§ IV. *Of Round Timber, whose Bases are equal.*

THE usual Way to measure Round Timber-trees, is to girt them about the Middle with a String, and take the fourth Part of that Girth for the Side of a Square, by which they measure the Piece of Timber as if it was square.

But that this is an Error, I shall make appear as follows. If the Circumference of a Circle be 1, the Area will be .07958; then the fourth Part of 1 is .25, which squared makes .0625; this they take for a mean Area, instead of .07958: Therefore the true Content always bears such Proportion to the Content found by the aforesaid customary false Way, as 0.7958 to .0625; which is nearly as 23 to 18; so that in measuring by that customary false Way, there is above the one-fifth Part lost of what the true Content ought to be.

This Error, though it has been so often confuted, yet it is grown so customary in all Places, that there is little Hope of my prevailing with Men that are so wedded to it, to embrace the Truth: I shall therefore, in the following Examples, shew how to work both the true Way, and also the false or customary Way.

Example 1. If a Piece of Timber be 96 Inches in Circumference or Girth, and 18 Feet long; How many Feet of Timber are contained therein?

A fourth Part of 96 is 24.

24	
24	
96	
48	
576 Area Base.	
18	Or thus,
4608	F. I.
576	2 0
	2 0
144)10368(72	
1008	4 0
	18
288	
288	72 0
...	

Content the false Way, 72 Feet.

Then

Then the true Way.

```
              96
              96
            ----
             576
            864
            ----
            9216
          .07958
          ------
           73728
          46080
         82944
        64512
        --------
        733.40928 the Area by Prob. 5. § IX. Ch. 2.
               18
        ---------
        586727424
        73340928
        ---------
144)13201.36704(91.67 Feet, the true Content.
    ---------
     241
      973
      1096
      ----
        88
```

By Scale and Compasses.

Extend from 12 to 24 (the fourth Part of the Girth) that Extent, turned twice over from 18 Feet (the Length) will at last fall upon 72 Feet, the Content the customary Way.

Extend from 42.54 to 96 (the Girth) that Extent will reach from 18 Feet, turned twice over, to 91.67 Feet, the true Content.

Example

Example 2. If a Piece of Timber be 86 Inches Girth and 20 Feet long; How many Feet are contained therein?

The fourth Part of 86 is 21.5

```
F. I. P.
1  9  6
1  9  6
-----------
1  9  6
1  4  1  6
   0  10 9
-----------
3  2  6  3
         20
-----------
64 2  5  0
```

```
         21.5
         21.5
         ----
         1075
         215
        430
        ------
        462.25
            20
        -------
144)9245.00(64.2
     -------
     605
      290
      ---
       20
```

The Content the false Way, 64.2 Feet.

By the true Way.

```
          86
          86
        ----
         516
        688
        ----
        7396
      .07958
     -------
       59168
      36980
     66564
    51772
    ---------
    588.57368
           20
   -----------
144)11771.47360(81.74
   -----------
    251
    1074
      667
     ----
       91
```

The true Content, 81.74 Feet.

By Scale and Compasses.

Extend from 12 to 21.5, that Extent, turned twice over from 20, will reach at last to 64.2 Feet, the Content the false Way.

Extend from 42.54 to 86, that Extent, turned twice over from 20, will at last fall upon 81.74 Feet, the true Content.

The Cylindrical Proportions may be very easily wrought upon the Line of Numbers.

Problem 1. Having the Diameter of a Cylinder in Inches, to find the Length of a Foot.

Suppose the Diameter 22.6 Inches.

As 22.6 is to 46.9, so is 1 to a fourth Number, and that to the Length of a Foot in Inches 4.3.

Extend the Compasses from 22.6 to 46.9, that Extent will reach from 1 to a fourth Number; then turn them over again, and that will reach to 4.3 Inches.

Problem 2. Having the Diameter in Foot-measure, to find the Length of a Foot in Foot-measure.

Suppose the Diameter 1.88 Feet.

Then, as 1.88 is to 1.28, so is 1 to a fourth Number: And so is that to the Length of a Foot in Foot-measure, .358.

Extend the Compasses from 1.88 to 1.128, that Extent, turned twice from 1, will reach to .358 Parts of a Foot.

Problem 3. Having the Circumference in Inches, to find the Length of a Foot in Inches.

Suppose the Circumference 71 Inches.

Then, as 71 is to 247.36, so is 1 to a fourth Number; and so is that to the Length of a Foot in Inches, 4.3.

Extend the Compasses from 71 to 147.36, that Extent turned twice from 1, will reach to 4.3 Inches, the Length of a Foot.

Problem 4. Having the Circumference in Foot-measure, to find the Length of a Foot in Foot-measure.

Suppose the Circumference 5.92 Feet.

Then, as 59.2 is to 3.345, so is 1 to a fourth Number; and so is that to the Length of a Foot in Foot-measure, .358.

Extend the Compasses from 5.92 to 3.545, that Extent, turned twice over from 1, will fall upon .358 Parts of a Foot.

Problem 5. Having the Diameter in Inches, and the Length in Inches, to find the Content in Inches.

Suppose the Diameter 22.6 Inches, and the Length 156 Inches, or 13 Feet.

Then, as 1 128 is to 22.6, so is 156 to a fourth Number; and so is that to the Content in Inches, 62674.

Extend the Compasses from 1.128 to 22.6, that Extent, turned twice from 156, will fall upon 62674 Inches, the Content.

Note, That 1.128 is the Diameter when the Side of the Square is equal to 1.

Problem 6 Having the Diameter in Foot-measure, and Length in Feet, to find the Content in Feet.

Suppose the Diameter 1.88 Feet, and the Length 13 Feet.

Then, as 1.128 is to 1.88, so is 13 to a fourth Number; and so is that to the Content in Feet, 36.27.

Extend from 1.128 to 1.88, that Extent, turned twice from 13, will fall upon 36.27.

Problem 7. Having the Diameter in Inches, and Length in Inches, to find the Content in Feet.

Suppose the Diameter 22.6 Inches, and the Length 156 Inches.

Then, as 46.9 is to 22.6, so is 156 to a fourth Number; and so is that to the Content in Feet, 36.27.

Extend from 46.9 to 22.6, that Extent, turned twice from 156, will fall upon 36.27 Feet, the Content.

Note, That 46.9 is the Diameter of a Circle, whose Area is 1728.

Problem 8. Having the Diameter in Inches, and Length in Feet, to find the Content in Feet.

Suppose the Diameter 22.6 Inches, and the Length 13 Feet.

Then, as 13.54 is to 22.6, so is 13 to a fourth Number; and so is that to the Content in Feet, 36.27.

Extend from 13.54 to 22.6, that Extent, turned twice from 13, will fall upon 36.27.

Note, That 13.54 is the Diameter of a Circle, when the Area is 144.

Problem 9. Having the Circumference in Inches, and Length in Inches, to find the Content in Inches.

Suppose the Circumference 71, and the Length 156 Inches.

Then, as 3.545 is to 71, so is 156 to a fourth Number; and so is that to 62674, the Content in Inches.

Extend the Compasses from 3.545 to 71, that Extent, turned twice from 156, will fall upon 62674, the Content.

Note, That 3.545 is the Circumference, when the Side of the Square is equal to 1.

Problem 10. Having the Circumference in Feet, and Length in Feet, to find the Content in Feet.

Suppose the Circumference 5.92 Feet, and Length 13 Feet.

Then, as 3.545 is to 5.92, so is 13 to a fourth Number; and so is that to 36.27.

Extend from 3.545 to 5.92, that Extent, turned twice from 13, will fall upon 36.27 Feet, the Content.

Problem

Problem 11. Having the Circumference in Inches, and Length in Inches, to find the Content in Feet.

Suppose the Circumference 71 Inches, and Length 156 Inches.

Then, as 147.36 is to 71, so is 156 to a fourth Number; and so is that to the Content in Feet 36.27.

Extend the Compasses from 147.36 to 71, that Extent, turned twice from 156, will fall upon 36.27 Feet, the Content.

Note, That 147.36 is the Circumference of a Circle, whose Area is 1728.

Problem 12. Having the Circumference in Inches, and Length in Feet, to find the Content in Feet.

Suppose the Circumference 71 Inches, and Length 13 Feet.

Then, as 42 54 is to 71, so is 13 to a fourth Number; and so is that to the Content in Feet, 36.27.

Extend the Compasses from 42.54 to 71, that Extent, turned twice from 13, will reach to 36.27 Feet, the Content.

Note, That 42 54 is the Circumference of a Circle, whose Area is 144.

§ V. *Of Round Timber, whose Bases are unequal.*

THE usual Way to measure Round Timber (as I said before) is to take a fourth Part of the Girth in the Middle of the Piece, for the Side of a mean Square. But this Way I have proved to be erroneous in Timber that is all the Way of an equal Thickness; and it must be much more so in Timber that is tapering; and the more tapering it is, the greater is the Error: For to the Error in the last Section, there is added the Error in the third Section; therefore, to measure all such Timber according to Art and Truth, such a Piece ought to be considered as a Frustum of a Cone, and should be measured by the Rules given in Sect. VIII. Chap. II. by which Rules the following Examples are wrought.

Example 1. If a Piece of Timber be 9 Inches Diameter at the lesser End, and 36 Inches at the other End, and 24 Feet long; How many Feet of Timber are therein?

	36	36	Subtract.
	9	9	
Rect.	324	27	Difference.
		27	
		189	
		54	
		3)729	the Square.
		243	One-third.
		324	Rectangle add.
		567	

.7854

```
              .7854
               567
            -------
              54978
             47124
            39270
            ---------
A mean Area  445.3218
                   24
            ---------
             17812872
             8906436
         ------------
     144)10687.7232(74.22
         ------------
             607
              317
               292
              ----
                 4
```

Anfwer, 74.22 Feet.

Or thus, by Feet and Inches.

F.	I.	
3	0	
0	9	
2	3	Rect.

F.	I.		
2	3		Difference.
2	3		
4	6		
0	6	9	
5	0	9	the Square.
1	8	3	One-third.
2	3	0	Rectangle added.
3	11	3	a mean Square.

Then,

Then, As 14 is to 11, so is 3 11 3 (F. I. P.) to the Area.

	F.	I.	P.	
	3	11	3	
			11	
7)	43	3	9	
2)	6	2	3	
	3	1	1	6
				6
	18	6	9	0
				4
	74	3	0	0

Here, instead of dividing by 14, I divide by 7 and by 2, because twice 7 is 14.

And instead of multiplying by 24 Feet, the Length, I multiply by 6 and 4, because 6 times 4 is 24.

By Scale and Compasses this is too troublesome.

Example 2. If a Piece of Timber be 136 Inches Circumference at one End, 32 Inches Circumference at the other End, and 21 Feet long; How many Feet of Timber are contained in that Piece?

```
 136          136
  32           32
 ----         ---
 272          104 Difference.
408           104
 ----         ---
4352          416
             1040
             -----
           3)10816 the Square.
             ------
             3605.333 One-third.
             4352     Rectangle add.
             --------
             7957.333 a mean Cir. squared.
              .07958
             --------
             63658664
            39786665
           71615997
          55701331
          ------------
          633.24456014 the mean Area.
                    21
          ------------
          63324456014
        1266489120028
        -------------
        13298.13576294

        144)13298.13(92.34
            ------
            338
             501
              693
              ---
              117

Answer, 92.34 Feet.
```

By

By Feet and Inches, thus;

F.	I.	
11	4	
2	8	
22	8	
7	6	8
30	2	8

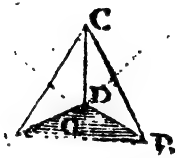
	F.	I.			
	8	8			Difference.
	8	8			
	69	4			
	5	9	4		
3)	75	1	4		the Square.
	25	0	5	4	
	30	2	8	0	
	55	3	1	4	the Sq. of the Circum

	F.	I.	P.	S.	
88 : 7 ::	55	3	1	4	: the mean Area.
				7	
11)	386	9 .	9	4	
8)	35	1	11	9	
	4	4	8	11	the mean Area.
				7	
	30	9	2	5	
				3	
Facit	92	3	7	3	

§ VI. *Of the Five Regular Bodies.*

THESE Bodies may all be meaſured by the fourth Section of Chap. II. except it be the Cube, or Hexaedron, which is already meaſured in Section I. of that Chapter.

1. *Of the* TETRAEDRON.



A Tetraedron is a Solid, contained under four equal and equilateral Triangles.

Let ABCD be a Tetraedron, whoſe Side is 12 Inches, the perpendicular Height 9.798 Inches.

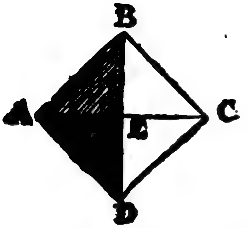
By Sect. V. Chap. I. the Area of the Triangle will be found 62.352; a third Part of it is 20.784, which multiplied by the perpendicular Height, the Product is 203.641632 ſolid Inches, the Content.

10.392	the Perpendicular of the Triangle.
6	Half the Side.
62.352	Area of the Triangle.
20.784	one-third Part.
9.798	the perpendicular Height.
166272	
187056	
145488	
187056	
203.641632	

The

The superficial Content is four times the Area of the Triangle, *viz.* 249 408 Inches, because there are four Triangles.

2. *Of the* OCTAEDRON.



The Octaedron is a Body contained under eight equal and equilateral Triangles.

Let ABCDE be an Octaedron, whose Side is 12 Inches; the Content solid and superficial is required.

An Octaedron is composed of two quadrangular Pyramids joined together by their Bases; therefore, if the Area of the Base be multiplied into a third Part of the Length of both Pyramids, the Product will be the solid Content.

```
5.6568 a third Part of the Length.
   144 Area of the Square Base.
------
 226272
226272
56568
------
814.5792 the Solidity.
```

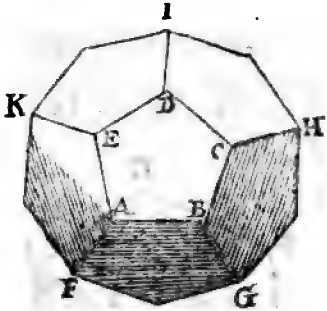
The superficial Content will be just double to that of the Tetraedron, *viz.* 498.816, because the Side of this is supposed to be equal to the Side of that, and because the Octaedron is contained under eight Triangles, and the Tetraedron but under four.

3. Of

3. *Of the* DODECAEDRON.

The Dodecaedron is a solid Body, contained under twelve pentangular Planes.

Let ABCDEFGHIK be a Dodecaedron, each Side thereof being 12 Inches; the Content, solid and superficial, is required.



The Solidity of the Dodecaedron is composed of 12 pentangled Pyramids, whose Vertexes all meet in the Center.

Therefore, if we find the Solidity of one of those Pyramids, and multiply that by 12, that Product will be the Solidity of the Dodecaedron.

The Altitude of one of the pentangled Pyramids will be found to be 13.36219.

The Perpendicular of the Pentagon will be

8.258292
30 half Sum of the Sides.

247.748760 Area of the Pentagon.
60454.4 a third Part of 13.36219 inverted.

99099504
9909950
1238744
99099
1486

1103.48783 Content of one Pyramid.
12

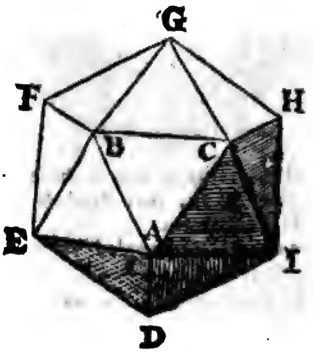
13241.85392 the Solidity of the Dodecaedron.

 If

If the Area of the Pentagon be multiplied by 12, the Product will be the superficial Content.

$$\begin{array}{r} 247.74876 \\ 12 \\ \hline 2972.98512 \end{array}$$ the superficial Content.

4. *Of the* ICOSAEDRON.



The Icosaedron is a solid Body, contained under twenty equal and equilateral Triangles.

Let ABCDEFGHI be an Icosaedron, each Side thereof being 12 Inches; the Content, solid and superficial, is required.

The Icosaedron is composed of twenty triangular Pyramids, with their Vertekes all joining in the Center.

Therefore, if the solid Content of one Pyramid be multiplied by 20, the Product is the whole solid Content of the Icosaedron.

10.39224 the Perpendicular of the Triangle.
6 Half the Side.

62.35344
20

1247.06880

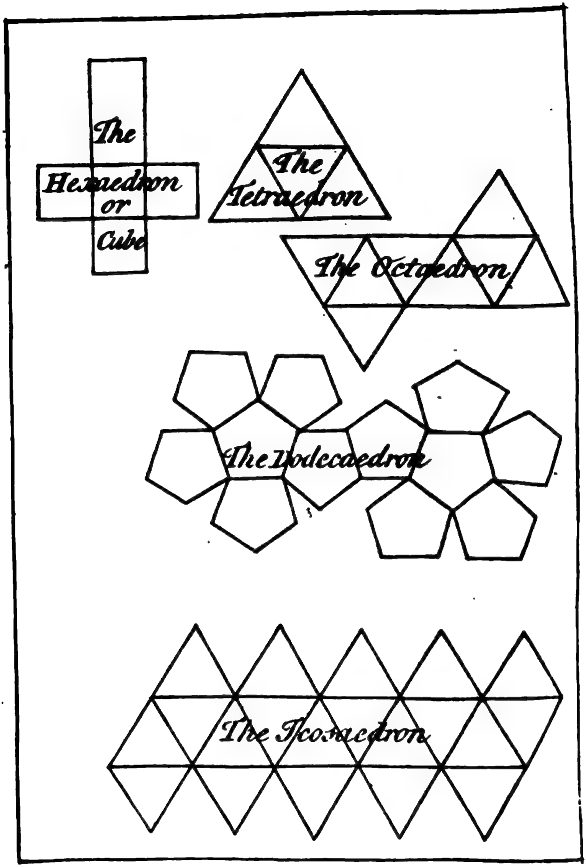
3.0230456 third Part of the Altitude of the Pyram.
44353.26

181382736
6046091
906914
151152
9009
1209
121

188.497292
20

3769.945840 the Solidity.

The superficial Content, 1247.0688.



By thefe Figures you may cut thefe Bodies in fine Pafteboard, cutting all the Lines half through, and fo turn them up and glue them.

A TABLE

A TABLE *shewing the Solidity and superficial Content of any of the Regular Bodies, the Side being* 1, *or Unity.*

The Names of the Bodies.	The Solidity.	Superficies.
Tetraedron	0.1178511	1.732051
Octaedron	0.4714045	3.464102
Hexaedron	1.0000000	6.000000
Icosaedron	2.181695	8.660254
Dodecaedron	7.663119	20 645729

By this Table, the Content, either superficial or solid, of any of these Bodies, may very readily be found; for all like superficial Figures are in Proportion one to another, as are the Squares of their like Sides: Therefore it will be, As the Square of 1, (which is 1) is to the superficial Content in the Table; so is the Square of the Side of the like Body, to the superficial Content of the same Body. Therefore, if the Number in the Table be multiplied by the Square of the Side given, the Product is the superficial Content required.

Again; all like Solids are in such Proportion to each other, as are the Cubes of their like Sides. Therefore it will be, As 1 (which is the Cube of 1) is to the solid Content in the Table, so is the Cube of the Side given, to the solid Content required. Therefore, if the Number in the Table be multiplied by the Cube of the given Side, the Product will be the solid Content of the same Body.

Example 1. If the Side of a Dodecaedron be 12 Inches (as before); What is the Content solid and superficial?

```
   7.663119 the tabular Number.
       1728 the Cube of the Side.
   ---------
   61304952
  15326238
 53641833
 7663119
-----------
13241.869632 the solid Content, nearly the same as
                                          (before.
     20.645729 the tabular Number.
           144 the Square of the Side.
     ---------
      82582916
     82582916
    20645729
    ----------
    2972.984976 the superficial Content.
```

By Scale and Compasses.

Extend from 1 to 12 (the Side) that Extent being turned three times over fom 7.63119, will at last fall upon 13241.86, &c. the solid Content.

And if you apply the same Extent twice from 20.645729, it will at last fall upon 2972.98, &c. the superficial Content.

Example

Example 2. If the Side of an Octaedron be 20 Inches; What is the Content solid and superficial?

.4714045	the tabular Number.
8000	the Cube of the Side.
3771.2360000	the solid Content.
3.464102	the tabular Number.
400	the Square of the Side.
1385.640800	the superficial Content.

By Scale and Compasses.

Extend from 1 to 20, that Extent, turned three times over from .4714045, will at last fall upon 3771.236, the solid Content. The same Extent, turned twice over from 3.464, &c. will at last fall upon 1385.64, the superficial Content.

§ VII. *How to measure any irregular Solid.*

IF you have any Piece of Wood or Stone that is craggy or uneven, (and you desire to find the Solidity, put the Solid into any regular Vessel, as a Tub, a Cistern, or the like, and pour in as much Water as will just cover it; then take out the Solid, and measure how much the Fall of the Water is, and so find the Solidity of that Part of the Vessel.

Example.

Example. Suppose a Piece of Wood or Stone to be measured, and suppose a Tub 32 Inches Diameter, into which let the Stone or Wood be put, and covered with Water; then, when the Solid is taken out, suppose the Fall of the Water 14 Inches; Square 32, and multiply the Square by .7854, the Product will be 804.2496, the Area of the Base; which multiplied by 14, the Depth or Fall of the Water, and the Product is 11259.49, *&c.* which divided by 1728, the Quotient is 6.51 Feet; and so much is the solid Content required.

CHAP. V.

Practical Questions in MEASURING.

Question 1. IF a Pavement be 47 Feet 9 Inches long, and 18 Feet 6 Inches broad, I demand how many Yards are contained therein?

F.	I.	
47	9	
18	6	
376	0	
47		
23	10	6
9	0	0
4	6	0
883	4	6

F. I.
47·75
18.5
23875
38200
4775
9)883.375
98.1

Answer, 98 Yards 1 Foot.

Quest.

Quest. 2. There is a Room, whose Length is 21.5 Feet, and the Breadth 17.5 Feet, which is to be paved with Stones, each 18 Inches square; I demand how many such Stones will pave it?

21.5	1.5
17.5	1.5
1075	75
1505	15
215	2.25 Area of one Stone.
2.25)376.25(167	
1512	
1625	
50	Answer, 167 Stones.

Quest. 3. There is a Room 109 Feet 9 Inches about, and 9 Feet 3 Inches high, which is all (except two Windows, each 6 Feet 6 Inches high, and 5 Feet 9 Inches broad, to be hung with Tapestry that is Ell-broad; I desire to know how many Yards will hang the said Room?

From the Content of the Room, subtract the Content of the Windows, and divide the Remainder by the square Feet in a Yard of Tapestry.

3.75	109.75 Length.	5.75
3	92.5 Breadth.	6.5
11.25	54875	2875
	21950	3450
	98775	
		37.375
	1015.1875 Content of the Room.	2
	74.75 Content of the Wind. sub.	
		74.750

11.25)940.4375(83.59

4043
6687
10925

500

Answer, 83.59 Yards.

Quest. 4. If the Axis of a Globe be 27.5 Inches; I demand the Content solid and superficial.

3.1416
27.5

157080
219912
62832

86.39.400 the Circumference.

86.394 the Circumference.
27.5 the Diameter.

431970
604758
172788

6)2375.8350 the superficial Content.

395.9725 a sixth Part.
27.5

19798625
27718075
7919450

1.889.24375

Answer, { 6.3 Feet solid.
16.49 Feet superficial.

Quest. 5. There is the Frustum of a Globe, the Diameter of whose Base is 24 Inches, and the Altitude thereof is 19 Inches; What is the Content solid and superficial?

Find the Superficies as is directed in Page 188, and the Solidity by the first Theorem in Page 190.

24	.7854	.7854	20
24	567	400	20
96	47124	314.1600	400
48	54978		
576	39270		

452.3904 } add.
314.16 }

766.5504 the Curve Superficies.
452.3904 the Base add.

1218.9408 { the whole superficial Content in Inches.

6 12

12×12=144
3

432
100 the Square of the Alt. add.

532 the Sum.
10 multiply by the Alt.

5320
5236 multiply.

31920
15960
10640
26600

2785.5520 the Solidity in Inches.

Quest. 6. If a Tree girt 18 Feet 6 Inches, and be 24 Feet long; How many Tons of Timber are contained in that Tree?

F. I.
4)18 6 the Girth.

4 7 6 a 4th Part.
4 7 6

18 6 0
2 8 4 6
2 3 9

21 4 8 3 Here I multiply by 6 and by
6 4, because 6 times 4 is 24.

128 4 1 6
4

|o)5 1|3 4 6 0

12 33

Answer, 12 Tons 33 Feet 4 Inches 6 Parts.

Note,

Note, That 40 Feet of Timber is a Ton, and 50 Feet a Load.

Note also, That 4 Feet broad, 4 Feet deep, and 8 Feet long, is a Chord of Fire-wood, that is, 128 cubical Feet.

Quest. 7. There is a Cellar to be dug by the Floor, whose Length is 33 Feet 7 Inches, and the Breadth is 18 Feet 9 Inches, and its Depth is to be 5 Feet 9 Inches; I demand how many Floors of Earth are in that Cellar?

F.	I.		
33	7		the Length.
18	9		the Breadth.
264			
33			
16	9	6	
8	4	9	
9	0	0	
1	6	0	
629	8	3	
5	9	0	the Depth.
3148	5	3	
314	10	1	
157	5	0	
324)3620	8	4(11	
380			
56			

Answer, 11 Floors 56 Feet.

Note, That 18 Feet square and a Foot deep is a Floor of Earth, that is, 324 solid Feet.

Quest.

Quest. 8. There is a Roof covered with Tiles, whose Depth on both Sides (with the usual Allowance at the Eaves) is 35 Feet 6 Inches, and the Length 48 Feet 9 Inches; How many Squares of Tiling are contained therein?

F.	I.	
48	9	
35	6	
240		
144		
24	4	6
17	6	0
8	9	0
17|30	7	6

Answer, 17 Squares 30 Feet.

Quest. 6. There is a Cone, whose Diameter at the Base is 42 Inches, and the perpendicular Height 94 Inches, and it is required to cut off two solid Feet from the Top-end thereof; I demand what Length upon the Perpendicular must be cut off?

42	1728	94
42	2	94
84	3456	376
168		846
1764		8836 Square.
.7854		94
7056		35344
8820		79524
14112		830584 the Cube.
12348		
1385.4456		
94		
55417824		
124690104		
3)130231.8864		
43410.6288		

All the solid Bodies are in triplicate Reason of their homologous Sides, by *Eucl.* 12, 12; 12, 18; and 11, 33: Therefore it will be,

Solidity of the Cone.	Cub. Alt.	Solidity of a Feet.
43410.6288 :	830584 ::	3456 :

830584
3456

4983504
4152920
3322336
2491752

434106288)2870498304(66124 the Cube of the Length.

265860576
5396803
1055740
187528

66124

66124(40.43
64

2124000 Resolvend.

12
48

492 Divisor.

120
4800

48120 Divisor.

64
1920
19200

1939264 Subtrahend.

184736000 Resolvend.

1212
489648

4897692 Divisor.

27
10908
1468944

147003507 Subtrahend.

37732493

Answer, The Length upon the Perpendicular must be 40.43 Inches. If it had been 3 Feet, the Length had been 46.29 Inches.

If two Feet were to be cut off from the Bottom, or greatest End, then from 43410.6288 subtract 3456, and the Remainder is 39954.6288. Then say,

```
43410.6288 : 830584 :: 39954.6288
                            830584
                       -----------
                         159818 5152
                        3196370304
                       1997731440
                      11986388640
                     3196370304
                    ----------------
43410.6288)33185675407.2192(764459(91.4
           ----------------   729
           279823524         -----
            19359751          35459
            1995500          ------
             259075              27
              42022            243
             ------           -----
               2952            2457
                              -----
                               271
                               243
                              ------
                               24571
                              ------
                               10888000
                              ---------
                                 273
                                24843
                               -------
                                248703
```

Answer, It must be cut at 91.4 Inches from the Top, or 2.6 Inches from the Bottom.

Quest. 10. If a square Piece of Timber be 12 Feet long, and if the Side of the Square of the greater Base be 21 Inches, and the Side of the Square of the lesser Base be 3 Inches; How far must I measure from the greater End, to cut off three solid Feet?

First find the Length of the whole Pyramid, thus; the Difference between 21 and 3 is 18: Then,

Diff. Length. great. Length.
As 18 : 12 : : 21 : 14.

So I find the whole Length of the Pyramid to be 14 Feet, or 168 Inches.

The solid Content of the whole Pyramid is 24696 Inches, and the solid Content of 5 Feet is 8640; which subtracted from 24696, there remain 16056 Inches. Then, the Cube of 168 (the Length) is 4741632. Then,

24696 : 4741632 : : 16056 : 3082752, whose Cube Root is 145.54; subtract this Root from 168 (the Length) and there remains 22.46 Inches, which is the Length of 5 solid Feet at the great End.

Quest. 11. Three Men bought a Grind-stone of 40 Inches Diameter, which cost 20 Shillings; of which Sum the first Man paid 9 Shillings, the second 6 Shillings, and the third 5 Shillings; I demand how much of the Stone each Man must grind down, proportionable to the Money he paid?

All Circles are in duplicate Reason of their Diameter, by *Eucl.* 12, 2.

Square the Semidiameter, which makes 400. Then

s. Square. s.
20 : 400 : : 9 : 180.

This 180 is the Square of the Semidiameter of the Circle belonging to the first Man.

s. s.
And, 20 : 400 : : 6 : 120.

This 120 is the Square of the Semidiameter of the Circle belonging to the second.

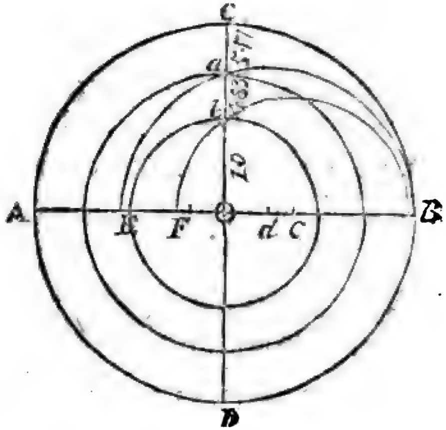
s. s.
And, 20 : 400 : : 5 : 100.

This 100 is the Square of the Semidiameter of the Circle belonging to the third.

Then, from 400 (the Square of the Semidiameter of the Stone) ſubtract 180; and there remains 220, whoſe ſquare Root is 14.83 Inches; which ſubtracted from 20 Inches, (the Semidiameter), there remain 5.17 Inches, which is the Breadth of the Ring, or Part of the Stone which muſt be ground down by the firſt.

Then, from 220 ſubtract 120, and there remains 100, whoſe Square Root is 10; ſubtract that from 14.83, and there remain 4.83 Inches, the Breadth of the Ring, or Part to be ground down by the ſecond Man. The third muſt grind down the Remainder, which is 10 Inches, the ſquare Root of 100.

This Queſtion may very eaſily and ſpeedily be performed geometrically, as in the annexed Scheme.



First, upon the Center ⊙ strike the Circle ABCD, and cross it at right Angles with the two Diameters AB and CD: Then divide the Semidiameter A ⊙ (which suppose 20) in Proportion to 9 s. 6 s. and 5 s. (the several Sums paid by the three Men) by the Points E and F; so shall AE be 9, EF 6, and F⊙ 5: Then divide EB into two equal Parts in d, and upon d, as a Center, strike the Semicircle E a B; and divide FB into two equal Parts in c, and upon c, as a Center, with the Radius cF, strike the Semicircle FbB: So have you the Semidiameter ⊙ C divided into three such Parts as the Stone ought to be divided; and Circles, struck through those Points, will shew how much each Man must grind for his Share.

Quest. 12. A Gard'ner he had an upright Cone,
Out of which should be cut him a Rolling-stone,
The biggest that e'er it could make:
The Mason he said, That there was a Rule
For such sort of Work, but he had a thick Skull:
Now help him for Pity's Sake.

Answer, It must be cut at one-third Part of the Altitude.

Quest.

Quest. 13. There is a Ciftern, whofe Depth is feven Tenths of the Width, and the Length is 6 times the Depth, and the folid Capacity is 367.5 Feet; I demand the Depth, Width, and Length, and how many Bufhels of Corn it will hold?

Firft, you muft find three Numbers in Proportion to the Depth, Width, and Length, thus: Suppofe the Depth 7, then the Width will be 10, and the Length 42; which multiplied together, the Product is 2940, which is the folid Inches in a Ciftern, whofe Depth is 7, Width 10, and Length 42. But the folid Inches in the Queftion are 635040 ($= 367.5 \times 1728$) then the Cube of fuppofed Width is 1000. So it will be,

2940 : 1000 : : 635040 : 216000, whofe Cube Root is 60, which is the true Width; 7 Tenths thereof is 42, the Depth; and 6 times 42 is 252 Inches, the Length; which three Numbers being multiplied together, the Product will be 635040. If thefe folid Inches be divided by 2150.42, and the Quotient is 295 [illegible] Bufhels, or 36 Quarters [illegible] Bufhels 1 Peck 4 Pints. And fo much will the Ciftern hold.

Quest. 14. Suppofe, Sir, a Bufhel be exactly round,
Whofe Depth being meafur'd, 8 Inches is found;
If the Breadth 18 Inches and half you difcover,
This Bufhel is legal all *England* over.
But a Workman would make one of another Frame;
Sev'n Inch and a half muft be the Depth of the fame;
Now, Sir, of what Length muft the Diameter be,
That it may with the former in Meafure agree?

```
          18.5
          18.5
          ----
           925
         1480
         185
        ------
        342.25 the Square.
          .7854
        -------
        136900
       171125
      273800
     239575
     ----------
     268.803150
              8
     ----------
    2150.425200 the solid Inches in a Bushel.

7.5)2150.4252(286.72336
       ...
      ---------
          650
           504
            542
             175
              252
               270
               450
              -----
                ...
```

.7854

.7854)286.72336

51103
39793
5236

)365.0666)19.107
1

29)265
261

381)406
381

38207)256600

Answer, The Diameter must be 19.107 Inches, if the Depth be 7.5 Inches.

Quest. 15. In the Midst of a Meadow well stored with Grass,
I took just an Acre to tether my Ass;
How long must the Cord be, that feeding all round,
He may'nt graze less nor more than his Acre of Ground?

By Problem 10. Section IX. Chap. I. find the Diameter of a Circle containing an Acre; half that will be the Length of the Cord.

The Work.

660 Feet, the Length of an Acre.
66 Feet, the Breadth of an Acre.

3960
3960

43560 the square Feet in an Acre.

As

As 1 : 1.2732 :: 43560

```
          43560
        -------
         763920
        63660
       38196
      50928
      -----------
      . . .
      55460.5920(235.5 Diameter.
      4           --------
     ----         117.75 half.
   43)154
      129
     -------
  465)2560
      2325
      -------
 4705)23559
      23525
      -------
         34
```

Answer, The Cord must be 117 Feet and 9 Inches.

Quest. 16. A Maltster has a Kiln, that is 16 Feet 6 Inches ſquare; but he is minded to pull it down, and build a new one, that may be big enough to dry three times as much at a time as the old one will do; I demand how much ſquare the new one muſt be?

```
        16.5
        16.5
       -----
         825
        990
       165
     -------
      272.25 the Area of the old one.
           3
     -------
      816.75(28 57
      4
     -----
  48)416
     384
     -----
 565)3275
     2825
     ------
5707)45000
      39949
      -----
       5051
```

Answer, The Side of the new one muſt be 22 Feet and near 7 Inches.

Quest. 17. If a round Ciftern be 26.3 Inches diameter, and 52.5 Inches deep; How many Inches diameter muft a Ciftern be to hold twice the Quantity, the Depth being the fame? And how many Ale Gallons will each Ciftern hold?

```
       26.3
       26 3
       ----
        789
      1578
      526
      ------
      691.69 Square.
           2
      ------
    1383.38(37.19
     9
   -----
   67)483
      469
      ----
  741)1438
       741
      -----
 7429)69700
      66861
      -----
       2839
```

The Diameter of the greater is 37.19 Inches.

 691.69

```
       691.69    the Square of the lesser Ci-
        .7854                     stern's Diameter.
       ------
       276676
      345845
     553352
    484183
   ----------
   543.253326   Area of the Base.
         52.5
   ----------
   2716266630
  1086506652
 2716266630
 -------------
 28520.7996150  solid Content in Inches.
 -------------
282)28520 799(101.137  Gallons.
 -------------
 320
  387
  1059
   219
   ---
   165
```

Note, That 282 solid Inches is an Ale or Beer Gallon, and 231 a Wine Gallon.

And 359.05 is the Square of the Diameter of a Circle that will hold a Gallon of Ale at an Inch deep, and 294.12 for Wine.

You

You may find the Content in Gallons, thus: Divide the Square of the Diameter by 359.05, and multiply the Quotient by the Depth.

```
359.05)1383.38       (3.853
                       52.5
       306230        ------
        18990         19265
         1037         7706
                     19265
                    -------
```

The Content of the greater, 202.2825 Gallons.

Quest. 18. If the Diameter of a Cask at the Bung be 32 Inches, and at the Head 25 Inches, and the Length 40 Inches; How many Ale Gallons are contained therein?

```
 25           32
 25           32
----         ----
125           64
50           96
----         ----
625          1024 Square of the Bung Diameter.
             1024 the same.
              625 Square of the Head Diameter.
             ----
      1077)2673         (2.48
           ----            40
            5190        ------
             8820        99.20
             ----
              204
```

Answer, 99.2 Gallons.

Otherwise you may find a mean Diameter, and work by Scale and Compasses, thus: Subtract 25 from 32, and there remains 7, which multiplied by .7, the Product is 4.9, which added to 25, the Sum is 29.9. Then extend the Compasses from 18.95 to 29.9, that Extent turned twice from 40 (the Length) will fall upon 99.6 Gallons; something more than before.

Quest. 19. There is a Stone, 20 Inches long, 15 Inches broad, and 8 Inches thick, which weighs 217 Pounds; I demand the Length, Breadth, and Thickness of another of the same Kind and Shape, which weighs 1000 Pounds?

The Cube of 20 (the Length) is 8000. Then (by *Eucl.* 11. 33.)

217 : 8000 : : 1000 : 36870.645, whose Cube Root is 38.28 Inches, the Length of the Stone weighing 2000 Pounds. Then say,

20 : 33.28 : : 15 : 24.96
20 : 33.28 : : 8 : 13.312

Answer, { The Length 33.28, The Breadth 24.96, The Thickness 13.312 } Inches.

Quest. 20. If an Iron Bullet, whose Diameter is 4 Inches, weighs 9 Pounds; What will be the Weight of another Bullet (of the same Metal) whose Diameter is 9 Inches?

The Cube of 4 is 64, and the Cube of 9 is 729. Then (by *Eucl.* 12. 18.)

lb. *lb.*
64 : 9 : : 729 : 102.515.
lb. *oz.* *dr.*
Answer, It weighs 102 8 4 *fere.*

Quest.

Quest. 21. There is a square Pyramid of Marble; each Side of its Base is 5 Inches, and the Height thereof 15 Inches, and its Weight is 12 Pounds and a Quarter; I demand the Weight of another like square Pyramid, each Side of whose Base is 30 Inches?

The Cube of 5 is 125, and the Cube of 30 is 27000. Then (by *Eucl.* 12. 12.)

lb. *lb.*
125 : 12.25 : : 27000 : 2646.

Answer, The Weight is 2646 Pounds.

Quest. 22. There is a Ball or Globe of Marble, whose Diameter is 6 Inches, and its Weight 11 Pounds; What will be the Diameter of another Globe of the same Marble, that weighs 500 Pounds?

The Cube of 6 is 216. Then,

lb. *lb.*
11 : 216 : : 500 : 981.1818.

Whose Cube Root is 21.4 Inches, the Diameter sought.

Quest. 23. There is a Frustum of a Pyramid, whose Bases are regular Octagons; each Side of the greater Base is 21 Inches, and each Side of the lesser Base is 9 Inches, and its Length is 15 Feet; I demand how many solid Feet are contained therein?

4.8284

```
  4.8284 the tabular Number, Page 88.
     237 the Square of a mean Side.
  ------
  337988            21          12
 144852              9          12
 96568             ---         ---
 ---------         189      3)144
 1144.3308          48         ---
        15         ---          48
 ---------         237
  57216540
 11443308
 ---------
144)17164.9620(119.2
    ----------
   276
   1324
     289
    ---
      1
```

Answer, 119.2 solid Feet.

Quest. 24. There is a Frustum of a Cone, the Diameter of the greater Base is 36 Inches, and the Diameter of the lesser Base is 20 Inches, and the Length or Height is 215 Inches; I demand the Length and solid Content of the whole Cone, and also the solid Content of the given Frustum?

First, Find the Length of the whole Cone, thus:

```
From 36
Subtr. 20
      --
      16 : 215 :: 36 : 483.75
```

So the Length of the whole Cone is 483¾ Inches.

Then

Then find the Content of the whole Cone.

36	1017.8784
36	52.161
216	10178784
108	6107270
	101788
1296	20357
.7854	5089
5184	1728)164132.88(94.98 Feet.
6480	8612
10368	17008
9072	14568
1017.8784 Area Base.	744

Thus I find the Solidity of the whole Cone 94.98 Feet.

Then find the solid Content of the Top-part that is wanting.

```
        .7854   the Area of Unity.
          400   the Square of 20.
      ---------
    3)314.1600  Area of the lesser Base.
      ---------
       104.72   a third Part.
       268.75   Altitude of the Top part.
      ---------
        52360
       73304
      83776
     62832
    20944
    -----------
1728)28143.5000(16.28 Feet.
    -----
    10863
      4955
      14990
      -----
       1166
```

	Feet.
Content of the Whole	94.98
Content of the Top-piece	16.28
Content of the Frustum	78.7

Quest. 25. If the Top part of a Cone contains 26171 solid Inches, and 200 Inches in Length, and the lower Frustum thereof contains 159610 solid Inches; I demand the Length of the whole Cone, and the Diameter of each Base?

```
   200          159610 } add.
     200         26171 }
   -----        ------
   40000        185781 the Sum.
       200
   -------
   8000000
```

26171 : 8000000 : : 185781 : 56789881, whose Cube Root is 384.3 Inches, the Length of the whole Cone.

Then find the Diameter of the lesser Base, thus:

```
200)26171
    ------
    130.855
          3
    -------
    392.565 Area of the lesser Base.
```

Then, by Prob. X. Sect. IX. Chap. I.

```
1 : .12732 : : 392.565
                1.2732
               -------
                785130
              1177695
             2747955
            785130
           392565
           ----------
           499.81375800(22.3
           4
           ---
           4 2)99
              84
              ---
          443)1581
              1329
              -----
         4465)25237
              22325
              -----
               2912
```

Again;

	Lesser Len.	Less. Diam.	Gr. Leng.	Gr. Diam.
Again;	200 :	22.35 ::	384.3 :	42.94.

		Inches.
Answer.	The Length of the whole Cone	384.3
	The Diameter of the greater Base	42.94
	The Diameter of the lesser Base	22.35

Quest. 26. There is a Frustum of a Cone, whose solid Content is 20 Feet, and its Length 12 Feet; and the greater Diameter bears such Proportion to the lesser as 5 to 2; I demand the Diameters?

5×5 = 25
2×2 = 4
5×2 = 10
The Sum 39

3)12
4)20(5 Feet.

These 5 Feet are the Triple of a mean Area.

Then, 1 : 1.27324 : : 5 : 6.3662.

So the triple Square of a mean Diameter is 6.3662.

Then, 39 : 6.3662 : : 25 : 4.080897.

This 4.080897 is the Square of the greater Diameter, whose Square Root is 2.020123 Feet; which is 24.24147 Inches. Then,

5 : 24.24147 : : 2 : 9.69659

So the greater Diameter is 24.24147, and the lesser Diameter is 9.69659 Inches.

Quest. 27. There is a Room of Wainscot 129 Feet 6 Inches in Circumference, and 16 Feet 9 Inches high (being girt over the Mouldings;) there are two Windows, each 7 Feet 3 Inches high, and the Breadth of each, from Cheek to Cheek, 5 Feet 6 Inches; the Breadth of the Shutters of each is 4 Feet 6 Inches; the Cheek-boards and Top and Bottom-boards of each

Window, taken together, is 24 Feet 6 Inches, and their Breadth 1 Foot 9 Inches; the Door-case 7 Feet high, and 3 Feet 6 Inches wide; the Door 3 Feet 5 Inches wide; I demand how many Yards of Wainscot are contained in that Room?

F.	I.	
129	6	
16	9	
782	0	
129		
64	9	
32	4	6
2169	1	6

F.	I.		
7	3		
4	6		
29	0		
3	7	6	
32	7	6	
16	3	9	half.
48	11	3	
		2	
97	10	6	

F.	I.		
3	3		
7	0		
22	9		
11	4	6	half.
34	1	6	

F.	I.	
24	6	
1	9	
4	6	
18	4	6
42	10	6
		2
85	9	0

F.	I.	
7	3	
5	6	
36	3	
3	7	6
39	10	6
		2
79	9	0

F.	I.	
3	6	
7	0	
24	6	add
79	9	
104	3	

The

The Content of the Room	2169	1	6
The Shutters, at Work and half	97	10	6
The Door, at Work and half	34	1	6
The Cheek-boards, &c.	85	9	0
The Sum	2386	10	6
The Window-lights and Door-case deduct	104	3	0
9)	2282	7	6
	253	5	

Answer, 253 Yards 5 Feet.

Quest. 28. There is a Wall which contains 18225 Cube Feet, and the Height is 5 times the Breadth, and the Length 8 times the Height; What is the Length, Breadth, and Height?

Suppose the Breadth 2, then the Height must be 10, and the Length 80; which three Numbers multiplied together, the Product will be 1600, and the Cube of 2 is 8: Then say,

1600 : 8 : : 18225 : 91.125.

Then the Cube Root of 91.125 is 4.5, which is the Breadth; then 5 times 4.5 is 22.5, the Height; and 8 times 22.5 is 180, the Length.

Quest. 29. There is a May-pole, whose Top-end was broken off by a Blast of Wind, and the Top-end, in falling, struck the Ground at 15 Feet Distance from the Top of the May-pole, the broken Piece was 39 Feet; Now I demand the Length of the May-pole?

By *Eucl.* 1..47, the Square of the Hypotheneuse of a right-angled Triangle is equal to the Sum of the Squares of the Base and Perpendicular.

There-

Therefore, from the Square of 39 ſubtract the Square of 15, the Square Root of the Remainder is the Piece ſtanding; to which add the Piece broken off, and you have the whole Length.

39	15
39	15
351	75
117	15
1521	225
225	
1296(36	
9	
66)396	
396	
...	

The Piece ſtanding is	36 Feet.
The Piece broken off is	39 Feet.
The whole Length	75

Queſtion 30.

A May-pole there was, whoſe Height I would know,
The Sun ſhining clear, ſtrait to work I did go:
The Length of the Shadow, upon level Ground,
Juſt ſixty-five Feet, when meaſur'd, I found;
A Staff I had there, juſt five Feet in Length;
The Length of its Shadow was four Feet One-tenth:
How high was the May-pole, I gladly would know?
And it is the Thing you're deſir'd to ſhow.

 By

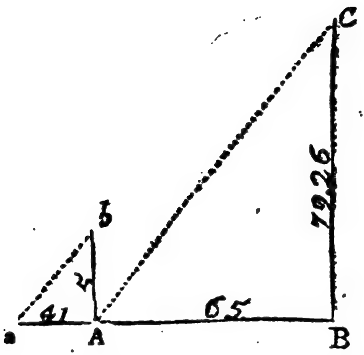
By *Eucl.* 6. 4.

a A : A b :: A B : B C

That is,

4.1 : 5 :: 65 : 79.26.

So I find the Height of the May-pole to be 75 Feet and a little above 3 Inches.



Here AB represents the Length of the Shadow of the May-pole, and BC the May-pole; a A the Shadow of the Staff, and A b the Staff.

Quest. 31. What will be the Diameter of a Globe, when the Solidity and superficial Content thereof are equal?

If the Diameter be 1, the Solidity will be .5236, and the Superficies will be 3.1416; that is, as 1 to 6. And to find the superficial Content, we must multiply 3.1416 by the Square of the Axis or Diameter, and the Product is the superficial Content. And for the Solidity, multiply .5236 by the Cube of the Axis, the

the Product is the solid Content; therefore, because .5236 is a sixth Part of 3.1416, we must take 6 for the Diameter sought. For if 3.1416 be multiplied by the Square of 6; *viz.* by 36, the Product will be 113.0976; and if .5236 be multiplied by the Cube of 6; *viz.* by 216, the Product is likewise 113.0976, the Solidity equal to the Superficies.

Therefore, 6 is the true Answer.

Quest. 32. What will the Axis of a Globe be, when the Solidity is in Proportion to the Superficies, as 18 to 8?

Because the Solidity and Superficies is as 1 to 6; when the Axis of the Globe is 1, it will be

$$8 : 18 :: 6 : 13.5.$$

So the Diameter sought is $13\frac{1}{2}$.

If the Proportion of the Solidity to the Superficies has been as 8 to 18, then it will be

$$18 : 8 :: 6 : 2\frac{2}{3}.$$

So then the Diameter will be $2\frac{2}{3}$.

The Reason of these Operations, both in this and the last Question, is from Algebra.

Quest. 33. There are three Grenado-shells, of such Capacity, that the second Shell will just lie in the Concavity of the first, and the third in the Concavity of the second. The Solidity of the Metal of the first Shell is equal to its Concavity; and the Solidity of the Metal to the second, to the Concavity, is as 7 to 5; and the Solidity of the third, or least Shell's Metal, to its Concavity, is as 9 to 4. Now, supposing the Diameter of the first, or greatest Shell, to be 16

 Inches,

Inches, and allowing every solid Inch of Iron to weigh 4 Ounces; I demand the Diameter of the two lesser Shells; and the Thickness and Solidity of Metal of every Shell; and also the Weight of every Shell?

The Cube of 16 is 4096; then,

1 : .5236 : : 4096 : 2144.6656.

The half thereof is 1072.3328, which is the Solidity of the Metal of the greater Shell, as also the Concavity.

.5236 : 1 : : 1072.3328 : 2048.

The Cube Root of 2048 is 12.699, which is the Diameter of the second Shell.

The Sum of 7 and 5 is 12; then,

12 : 5 : : 1072.3328 : 446.805.

This 446.805 is the solid Content of the Concavity of the second.

.5236 : 1 : : 446.805 : 853.333.

The Cube Root of 853.333 is 9.485, the Diameter of the least Shell.

The Sum of 9 and 4 is 13; then,

13 : 4 : : 446.805 : 137.47846.

This 137.47846 is the solid Content of the Concavity of the third.

.5236 : 1 : : 137.47846 : 262.5639.

The Cube Root of 262.5639 is 6.4034, the Diameter of the least Shell's Concavity.

From	16	the Diameter of the greatest,
Subtr.	12.699	the Diameter of the second.
Rem.	3.301	

Half is = 1.65 the Thickness of Metal of the greatest.

From

From	12.699	the Diameter of the ſecond,
Subt.	9.485	the Diameter of the leaſt.
Rem.	3.214	
Half is =	1.607	the Thickneſs of Metal of the ſecond.

From	9.485	the Diameter of the leaſt,
Subtr.	6.403	the Diameter of the Concavity.
Rem.	3.082	
Half is =	1.521	the Thickneſs of Metal of the leaſt.

The Metal of the greateſt is 1072.33 ſolid Inches; which divide by 4 (becauſe every ſolid Inch is a Quarter of a Pound) the Quotient is 268.08 Pounds.

The Metal of the ſecond is 625.52 ſolid Inches; which divided by 4, the Quotient is 156 38 Pounds, the Weight of the ſecond.

The Metal of the leaſt Shell is 309.32 ſolid Inches; which divided by 4, the Quotient is 77.33 Pounds, the Weight of the leaſt.

The Diameter of the	ſecond Shell	12.699	Inches.
	leaſt Shell	9.485	
The Thickneſs of the Metal of the	greateſt	1.65	Inches.
	ſecond	1.607	
	leaſt	1.541	
The Weight	greateſt	268.08	Pounds.
	ſecond	156.38	
	leaſt	77.33	

A SHORT

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

A SHORT

APPENDIX.

§ I. *Of* GAUGING.

I SHALL not here give the whole Art of Gauging (there being ſeveral Books of that Art already in Print, written by better Hands); but ſhall only lay down ſome ſhort practical Rules, whereby any Artificer, or others, may find the Quantity of Liquor in any Veſſel upon Occaſion.

PROBLEM I.

To find the ſeveral Multipliers, Diviſors, and Gauge-points, belonging to the ſeveral Meaſures now uſed in England.

282)1.0000(.003546 Multiplier for Ale Gallons.
231)1.0000(.004329 Multiplier for Wine Gallons.
268.8)1.000(.0037202 Multiplier for Corn Gallons.
2150.42)1.000(.00046502 Multipl. for Corn Buſhels.

So, if the ſolid Inches in any Veſſel be multiplied by the ſaid Multipliers, the Product will be Gallons in

in the respective Measures; or dividing by the Divisors 282.231, or 268.8, the Quotient will likewise be Gallons.

Note, That 282 solid Inches is a Gallon of Ale or Beer-measure; 231 solid Inches is a Gallon of Wine-measure; 268.8 solid Inches is a Gallon, and 2150.42 solid Inches is a Bushel of Corn-measure.

For circular Areas, the following Multipliers and Divisors are to be used.

282).785398(.002785 Multipliers for Ale Gallons.
231).785398(.003399 Multiplier for Wine Gallons.
.785398(282.(359 05 Divisor for Ale Gallons.
.785398(231.(294.12 Divisor for Wine Gallons.
.785398(2150.42(2738 Divisor for Corn Bushels.

The Square Root of the Divisor is the Gauge-point.

The Gauge-point for Squares in	Ale measure, is	16.79
	Wine-measure, is	15.19
	Malt-bushel, is	46.36
The Gauge-point for circular Figures in	Ale-measure, is	18.95
	Wine-measure, is	17.15
	Malt-bushel, is	52.32

PROBLEM II.

To find the Area in Ale or Wine Gallons, of any rectilineal plain Figure, whether Triangular, Quadrangular, or Multangular.

TO resolve this Problem, you must, by Chap. I. Part II. find the Area in Inches, and then bring it to Gallons, by dividing that Area in Inches by the proper Divisor; *viz.* by 282 for Ale, or by 231 for Wine; or else by Multiplication, by .003.546 for Ale, or by .004329 for Wine; and the Quotient or Product will be the Area.

Example.

Example. Suppose a Back or Cooler in the Form of a Parallelogram, or long Square, 250 Inches in Length, and 84.5 Inches in Breadth; What is the Area in Ale or Wine Gallons?

Multiply 250 by 84.5, and the Product is 21125, the Area in Inches, which divide by 282, and the Quotient is 74.9 Gallons of Ale; or multiplied by .003546, the Product is 74.20928 Gallons, nearly the same; and if 21125 be divided by 231, or multiplied by .004329, it will give 91.44 Gallons of Wine.

By Scale and Compasses.

Extend the Compasses from 282 to 250, that Extent will reach from 84.5 to 74.9. And,

Extend from 231 to 250, that Extent will reach from 84.5 to 91.45.

Note, The Areas of all Superficies are always to be understood to be 1 Inch deep; otherwise it could not be said, that the Area of such a Parallelogram, Circle, &c. is so many Gallons.

Having found the Area of a Back or Cooler, the next Thing will be to find out the true Dipping or Gauging-place in that Back, that so the true Quantity of Worts may be computed at any Depth; which may be thus done.

1. When the Bottom of the Back is covered all over (of any Depth) with Worts, or other Liquor, then dip it in eight or ten several Places (more or less, according to the Largeness of the Back), as remote and equally distant from each other as you can well do, noting down the wet Inches and decimal Parts of every Dip.

2. Divide the Sum of all those Dips by the Number of Places you dipped in, and the Quotient will be the mean Wet of all those Dips.

3. Lastly, find out such a Place by the Side of the Back (if you can) that just wets the same with that mean Dip, and make a Notch or Mark there for the true and constant Dipping-place of that Back.

Then if any Quantity of Worts (which covers the whole Back) be deped or gauged at that Place, and the wet Inches so taken be multiplied into the Area of the Back in Gallons, the Product will shew how many Gallons of Worts are in that Back at that time, provided the Sides of the Back do stand at Right-angles with the Bottom.

PROBLEM III.

The Diameter of a Circle being given in Inches, to find the Area thereof in Ale or Wine Gallons.

IF the Square of the Diameter be multiplied by .002785 for Ale, or by .003399 for Wine; or if it be divided by 359.05 for Ale, or by 294.12 for Wine, the Products or Quotients will be the respective Ale or Wine Gallons.

Example. Suppose the Diameter of a Circle be 32.6 Inches; What will be the Area in Ale or Wine Gallons?

The Square of 32.6 is 1062.76.

Then 359.05)1062.76(2.9599 Area in Ale Gallons.
And 294.12)1062.76(3.6133 Area in Wine Gallons.
Or 1062.76 × .002785 = 2.9598 Ale Gallons.
And 1062.76 × 0333993 = .6133 Wine Gallons.

By

By Scale and Compasses.

Extend the Compasses from 18.95 (the Gauge-point for Ale) to 32.6 (the Diameter) that Extent will reach from 1 to a 4th Number, and from that 4th to 2.9599 Gallons. Or, extend the Compasses from 1 to 32.6, that Extent, turned twice over from .002785, will at last fall upon 2.9599.

For Wine extend from 17.15 (the Gauge-point for Wine) that Extent, turned twice over from 1, will at last fall upon 3.6133 Gallons.

Or thus: Extend from 1 to 32.6, that Extent will reach from .003299, being twice turned over, to 3.6133 Wine Gallons.

PROBLEM IV.

The Transverse (or longest Diameter) and the Conjugate (or shortest Diameter) of an Ellipsis (or Oval) being given, to find its Area in Ale or Wine Gallons.

IF the Rectangle, or Product of the two Diameters, that is, of the Length and Breadth of the Oval, be divided by 359.05, or multiplied by .002785 for Ale, or divided by 294.12, or multiplied by .003399 for Wine, the Quotient or Product will be the Ale or Wine Gallons required.

Example. Suppose the longest Diameter be 81.4 Inches, and the shortest Diameter be 54.6 Inches: What will be the Area of that Oval?

Mulitply 81.4 by 54.6, and the Product is 4444.44; then,

359.05)4444.44(12.38 Area in Ale Gallons.
294.12)4444.44(15.11 Area in Wine Gallons.
Or 4444 44×.002785=12.38 Ale Gallons.
And 4444 44×003399=15.11 Wine Gallons.

By Scale and Compasses.

First, find a mean Proportional between 81 4 and 54 6, by dividing the Distance between them into two equal Parts, and the middle Point will be at 66.6, which is the mean Proportional (that is, the Diameter of a Circle equal to the Oval.) Then extend the Compasses from 18.95 (the Gauge-point for Ale) to 66.6, that Extent, turned twice over from 1, will at last fall upon 12.38, Ale Gallons: And extended from 17.15 (the Gauge-point for Wine) to 66.6; that Extent, turned twice over from 1, will reach at last to 15.11 Wine Gallons.

PROBLEM V.

To find the Content in Ale or Wine Gallons of any Prism, whatsoever Form its Base is of.

FIRST, find its solid Content in Inches (by Sect. I, II, III. of Chap. II. Part II.) then divide that Content in Inches by 282 for Ale, or by 231 for Wine; the respective Quotients will be the Content in Wine or Ale Gallons.

Otherwise, you may find the Content of a Prism by finding the Area of its Base in Gallons (by Problem II. of this Appendix) and multiply that Area by

by the Tun's Height, or Depth within, the Product will be its Content in Gallons.

Example. Suppose a Tun, whose Base is a Parallelogram right-angled, its Length being 49.3 Inches, its Breadth 36.5 Inches, and the Depth of the Tun is 42.6 Inches; the Content in Ale and Wine Gallons is required.

The Length, Breadth, and Depth, being multiplied continually, the Product is 76656.57; which divided by 282, the Quotient is 271.83 Ale Gallons: And divided by 231, the Quotient is 331.84 Wine Gallons: And by dividing by 2150.4, such a Cistern will be found to hold 35.65 Bushels of Corn.

By Scale and Compasses.

Extend the Compasses from 282 to 36.5, the Breadth of the Base, that Extent will reach from 49.3, its Length, to 6.38 Ale Gallons, the Area of the Base; then extend from 1 to 42.6, the Depth, that Extent will reach from 6.38, the Area of the Base, to 271.8 Gallons the Content.

PROBLEM VI.

To find the Content of a Tun, whose Bases are alike and parallel, but unequal, being the Frustum of a Pyramid.

FIND the Area of each Base, and a mean Proportional between them, and multiply the Sum of those three by one third Part of the Depth or Height, and the Product is the Content.

Example. Suppose a Tun, whose Bases are Parallelograms; the Length of the greater is 100 Inches, and its Breadth 70 Inches; the Length of the lesser Base 80, and its Breadth 56; and the Depth of the Tun 42 Inches; the Content in Ale and Wine Gallons is required.

Multiply 100 by 70, the Product is 7000, the Area of the greater Base; and 80 multiplied by 56, the Product is 4488, the Area of the lesser Base; then multiply the two Areas into each other; and the Product is 31360000, whose Square Root is 5600, a geometrical mean Proportional.

The greater Area	7000	add.
The lesser Area	4480	
The mean Proportional	5600	
	17080	
A third of the Depth	14	
	68320	
	17080	

282)239120(847.94 A. g.

231)239120(1035.15 W. g.

PROBLEM

PROBLEM VII.

To find the Content of a Tun, whose Bases are parallel and circular, being the Frustum of a Cone.

YOU may find the Content as in the last Problem, by multiplying the Sum of the Areas of the two Bases, and a mean Proportional, by one third Part of the Depth.

But it will be a shorter Way to find the Area of a mean Circle in Gallons, and multiply that by the Depth, thus: To the Rectangle of the greater and lesser Diameters add one third Part of the Square of the Difference of the Diameters; that Sum is the Square of a mean Diameter, which, divided by 359.05 for Ale, or by 294.12 for Wine, gives the Area of a mean Circle in Ale or Wine Gallons, which, multiplied by the Depth, gives the Content.

Example. Suppose the greater Diameter 80 Inches, and the lesser Diameter 71 Inches, and the Depth 34 Inches, the Content in Ale or Wine Gallons is required.

Multiply 80 by 71, and the Product is 5680; to which add 27 (a third Part of the Square of the Difference of the Diameters) and the Sum is 5707, which is the Square of a mean Diameter; which divide by 359.05, and the Quotient will be 15.895 Gallons the Area; which multiply by .34 (the Depth), and the Product will be 540.43 Gallons, the Content.

By Scale and Compasses.

Add the two Diameters together, and take half the Sum, which is 75.5, which take for a mean Diameter (though it is not exact, yet it will be near enough the Truth, if the Difference between the Diameters be not great); extend the Compasses from 18.95 (the Gauge-point for Ale) to 75 5, the mean Diameter; that Extent will reach from that 34 (the Depth) to a fourth Number, and from that to 540.4 Gallons, the Content.

And if you extend the Compasses from 17.15 (the Gauge point for Wine) to 75.5, that Extent will reach from 34, twice turned over, to 659 7 Gallons of Wine.

The Method used by the Gaugers for all such Tuns, is to take the Diameter in the Middle of every 10 Inches; that is, at five Inches from the Bottom, and at 15, and at 25, *&c.*

Then they find the Area to every one of these Diameters, and enter them in their Books. Then, when they survey, they take the wet Inches and Parts that the Liquor in the Tun is in Depth, and every 10 Inches they take the respective Areas, and remove the separating Point one Place towards the Right-hand; and for what odd Inches of the Depth above the even Tens, they multiply the next Area by them, and so add all the several Products together, and the Total will be the Gallons of Liquor in the Tun.

Example. Suppose the Diameter at 5 Inches from the Bottom 64 Inches, and at 15 Inches from the Bottom 67 Inches, and at 25 Inches 70 Inches, and at 35 Inches from the Bottom, the Diameter is 73 Inches. Now the Area answering to 64 Inches is 11.4078 Gallons; and to 67 Inches, is 12.5023 Gallons; and the Area to 70 Inches, is 13.647 Gallons; and to 73, is 14.8418 Gallons: Then, supposing the Depth of the Liquor in the said Tun be found

found to be 3.6 Inches: Now, to cast up this Gauge, first, in the Area answering to 64 Inches, being multiplied by 10, that is by removing the separating Point a Place towards the Right-hand, it will be 114.078 Gallons; and the next will be 125.023; and the next 136.47 Gallons. Now these three will be the Content to 30 Inches deep. Then, to find the Content of the 3.6 Inches, multiply the next Area 14.8418 by 3.6, and the Product is 53.4305: Add all together, and the Sum is the whole Quantity of Liquor in the Tun.

The Content at 10 Inches deep	114.078
The Content at the next 10 Inches	125.023
The Content at the next 10 Inches	136.470
The Content of the 3.6 Inches	53.430
The whole Quantity of Liquor in the Tun — —	429.001

PROBLEM VIII.

To find the Drip or Fall of a Tun.

SUppose the Tun last mentioned was so placed, that when the Bottom is but just covered on one Side, the Liquor is 4 Inches deep on the Side opposite; How much must be allowed for the Fall of this Tun? That is, How much Liquor is there in the Tun?

The Diameter in the Middle of 4 Inches from the Bottom, is 61.6 Inches; and the Area answering thereunto is 10.568; which multiplied by 2 (that is, half 4), the Product is 21.136 Gallons; and so much Liquor will just cover the Bottom.

But,

But, suppose it was set so much on one Side, as to be 30 Inches deep on one Side, when the Liquor on the opposite Side just cuts between the Bottoms and Staves; How much Liquor will there be in the Tun?

Square the Bottom Diameter, and multiply that Square by the Top Diameter, and divide the last Product by the Sum of the Diameters, and to the Quotient add the Square of the Bottom Diameter, and divide the Sum by 1077.15 for Ale, or by 882.36 for Wine; multiply the Quotient by the Depth, the Product is the Content.

The Bottom Diameter of the fore-mentioned Tun is 61 Inches; and the Diameter, at 30 Inches from the Bottom, is 71.5 Inches; the Square of 61 is 3721; which multiplied by 71.5, the Product is 266051.5; this divided by 132.5 (the Sum of the Diameters) the Quotient is 2007.936: To which add 3721 (the Square of 61), and the Sum will be 5728.936; this divided by 1077.15, the Quotient is 5.3186; which multiplied by 30, the Depth, the Product is 159.558, the Gallons of Liquor in the Tun.

When the Frustum of a Cone or Pyramid is cut, by a diagonal Plane, through the Extremities of the Diameters, as the Liquor in the Tun represents, such Solid is called a Hoof. (Vide *Ward's Young Mathematician's Guide*, Page 414.)

If it be the Hoof of a square Frustum, instead of dividing by 1077.15, divide by 846 for Ale, or by 693 for Wine. All the rest of the Work is the same.

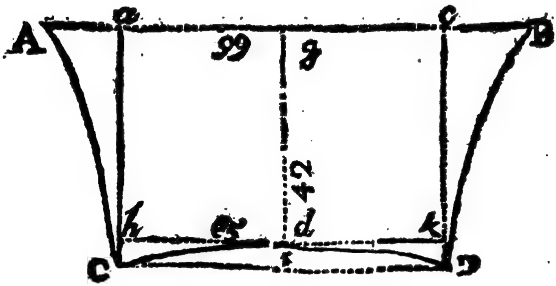
PROBLEM

PROBLEM IX.

To gauge a Copper.

LET ABCD be a small Copper to be gauged.

Take a small Cord of Packthread, make one End fast at A, and extend the other to the opposite Side of the Copper at B, where make it fast, or cause some Person to hold it very strait; then set one End of the Instrument in the Bottom of the Copper at C, and move it to and fro, till you find the nearest Distance to the Thread (as at *a*): This Distance, *a* C, is the Depth of the Copper, which suppose to be 47 Inches.



In like manner, set the End of the Rule upon the Top of the Crown at *d*, and take the nearest Distance to the Thread, as *dg*, which suppose 42 Inches: This subtracted from *a* C, 47, the Remainder 5 is the Altitude of the Crown.

To find CD, the Diameter of the Bottom of the Crown.

Measure AB, the Diameter of the Top, which admit to be 99 Inches; then hold a Thread so as a Plummet at the End thereof may hang just over C,

by which means you will find the Distance A *a*. Do the like on the other Side; so will you find also the Distance, B; which suppose 17.5 Inches each; add these two together, and subtract their Sum (*viz.* 35) from 99, and the Remainder is 64 Inches, the Diameter at the Bottom of the Crown. The Diameter which touches the Top of the Crown, may be found by the Sliding-rule to be 65 Inches.

Now to find the Content of the Copper from the Crown upwards, that is, the Part A B *k b*, the Depth *g d* being 42 Inches, you may take the Diameter in the Middle of every 6 Inches of the Depth, which suppose to be as in the second Column of the following Table, the Numbers in the third Column are the respective Areas in Ale Gallons, found by Problem III. the fourth Column shews the Content of every 6 Inches; all which being added together, the Sum will be the Content of that Part, A B *k b*; that is, so much as it will hold after the Crown is covered.

Now, if the Crown be taken for the Frustum of a Sphere, the Content (by the latter Part of Sect. II. Page 190.) will be found to be 28.75 Gallons.

But may be more readily found, very near the Truth, thus:

The Diameter CD was found to be 64, and the Area to this Diameter is 11.408; this, multiplied by half the Crown's Altitude, *viz.* by 2.5, gives 28.52 Gallons, the Content of the Crown.

The Content of the Part *bk*DC is 57.935 Gallons; from which subtract the Content of the Crown, 28 52, and the Remainder is 29.415 Gallons, and so much Liquor will just cover the Crown.

Parts

Parts of the Depth.	Diameter.	Areas.	Content of every 6 Inches.
6	95.3	25.2945	151.767
6	90.1	22.6095	135.657
6	85.0	20.1223	120.734
6	80	17.8246	106.947
6	75.2	15.7499	94.499
6	70.5	13.8426	83.056
6	66	12.1319	72.791
The Sum	—	—	765.451
To just cover the Crown		—	29.415
The whole Content		—	794.866

By Scale and Compasses.

You may find the Areas answering to every one of the Diameters, thus:

Extend the Compasses from the Gauge-point to the Diameter; that Extent being turned twice over from 1, will at last fall upon the Area of that Circle: Or, being turned twice over from 6, will give the Content of that 6 Inches of the Depth.

Example. Extend the Compasses from 18.95 (the Gauge-point) to 95.3; that Extent, turned twice over from 6, will at last fall upon 151.76 Gallons, the Content of the first 6 Inches. And so of the rest.

PROBLEM X.

To compute the Content of any close Cask.

IN order to perform this difficult Part of Gauging, the three following Dimensions of the Cask must be truly taken;

Viz. { The Bung-diameter, The Head-diameter, The Length of the Cask, } within the Cask.

In taking these Dimensions, it must be carefully observed,

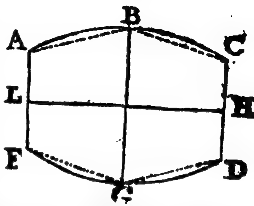
1. That the Bung-hole be in the Middle of the Cask; also, that the Bung-staff, and the Staff opposite to the Bung-hole, are both regular and even within.

2. That the Heads of the Cask are equal, and truly circular; if so, the Distance between the Inside of the Chine to the Outside of its opposite Staff, will be the Head-diameter within the Cask, very near.

3. With a sliding Pair of Calipers (made for that Use) take the shortest Distance, or Length, between the Outsides of the two Heads; from that Length subtract $1\frac{1}{5}$ Inch (more or less according to the Largeness of the Cask) for the Thickness of the Head: The Remainder will be the Length of the Cask within. But if the Cask be empty, you may take the Length, by putting a strait Rod in at the Tap-hole, and allow for the Thickness of the Head.

Now by these Dimensions, one would think the Content of the Cask was perfectly limited; but it will be easy to perceive, by the following Figure, that the

the Diameters and Length of one Cask may be equal to those of another, and yet one of those Casks may contain several Gallons more than the other.



As for Instance, the Figure ABCDF is supposed to represent a Cask: Then it is plain, that if the outward curve Lines, ABC, and FGD, are the Bounds or Staves of the Cask, it must needs hold more than if the inner pricked Lines were the Bounds, or Staves and yet the Bung-diameter BG, and Head-diameters CD and AF, and the Length LH, are the same in both those Casks.

Whence it appears, that no one general Rule can be given, whereby the Content of all Sorts of Casks can be gauged: And therefore Gaugers do usually suppose every Cask to be in some of these Forms:

1. The middle Frustum of a Spheroid.
2. The middle Frustum of a parabolic Spindle.
3. The lower Frustums of two equal parabolic Conoids.
4. The lower Frustums of two equal Cones.

1. If the Staves of a Cask be very much curved (as the outward Lines of the last Figure), then the Cask is supposed to be the middle Frustum of a Spheroid.

2. If the Staves (between the Bung and the Head) be something less curved, then the Cask is taken to be the middle Frustum of a parabolic Spindle.

3. If the Staves (between the Bung and Head) be very little curved, then the Cask is taken to be the lower Frustums of two equal parabolic Conoids,

 abutting

abutting or joining together upon one common Base.

4. If the Staves between the Bung and Head be ſtrait (as the pricked Lines in the laſt Figure), then the Caſk is taken to be the lower Fruſtums of two equal Cones, abutting or joining together upon one common Baſe.

There are ſeveral Rules laid down in Books of Gauging, for finding the Content of each ſeveral Form; but I think the ſhorteſt and moſt practical Way is, to find ſuch a mean Diameter, which will reduce the propoſed Caſk to a Cylinder: Thus,

Multiply the Difference of the Bung and Head Diameters by .7 for the Spheroid; by .65 for the ſecond Form, by .6 for the third Form, and by .55 for the fourth Form; and add the Product to the Head-diameter, and the Sum is the mean Diameter.

Example. Suppoſe the Bung-diameter be 32 Inches, the Head-diameter 24 Inches, and the Length 40 Inches; the Content in each Variety is required.

The Difference between the Bung and Head-diameter is 8; which multiplied by .7, the Product is 5.6; which added to the Head-diameter, the Sum is 29.6, the mean Diameter: The Area anſwering thereunto will be found (by Prob. III.) to be 2.44 Ale Gallons; which multiplied by the Length, the Product is 97.4 Gallons; and ſo much is the Content, if it be the firſt Form.

Again; if the Difference of the Diameters 8 be multiplied by .65, the Product will be 5.2; which added to the Head-diameter, the Sum is 29.2, for the mean Diameter; and the Area anſwering thereunto is 2.3746 Gallons; which multiplied by 40 (the Length) the Product is 94.98 Gallons, the Content, if it be of the ſecond Form.

Again;

Again; if the Difference 8 be multiplied by 6, the Product is 4.8; which added to the Head-diameter, the Sum is 28.8, the mean Diameter: The Area thereunto is 2.31 Gallons; which, multiplied by 40, gives the Content 92.4 Gallons, for the third Form.

Again; the Difference 8, multiplied by .55, the Product is 4.4; which added to the Head-diameter, makes the mean Diameter 28 4; the Area thereof is 2.2463; which multiplied by 40, the Product is 89.85 Gallons, for the fourth Form.

By Scale and Compasses.

Extend the Compasses from the Gauge-point 18.95 to the first mean Diameter 29.6; that Extent will reach from the Length 40 to a fourth Number, and then to the Content, 97.4 Gallons.

Again; extend from 18.95 to 29.2 (the second mean Diameter) that Extent, turned twice over from 40, will at last fall upon 94 98 Gallons.

Again; extend from 18 95 to 28.8 (the third mean Diameter) that Extent, turned twice over from 40, will at last fall upon 92.4 Gallons.

Again; extend from 18.95 to 28 4 (the fourth mean Diameter) that Extent, turned twice over from 40, will at last fall upon 89.85 Gallons.

Although I have all along made use of the Line of Numbers upon the common Two-foot or Eighteen-inch Rules, for the Reason mentioned in the *Preface*; yet the Rules may easily be applied to the Sliding-rule, thus: To find the Area of a Circle in Gallons, set the Gauge-point upon D (that is, a single Line of Numbers) to 1 upon C (that is, a double Line;)

 then

then against any Diameter upon D, is the Area upon C, thus;

To find the Content of the Cask, last mentioned, the first Form.

Set the Gauge-point 18.95 upon D, to the Length 40 upon C; then (against the mean Diameter) 29.6 upon D, is 97.4 Gallons, the Content upon C.

And against 29.2 (the next mean Diameter) on D, is 94.98 Gallons on C.

And against 28.8 (the next mean Diameter) on D, is 92.4 Gallons on C.

And against 28.4 (the last mean Diameter) on D, is 89.85 Gallons on C.

All done without removing the Slider.

A TABLE

A TABLE *of the Segment of a Circle, whose Area is Unity.*

V. S.	Segm.	V. S	Segm.	V. S.	Segm.	V. S.	Segm.
1	0017	99	.9983	26	.2066	74	.7924
2	.0048	98	.9952	27	.2178	73	.7832
3	.0087	97	.9913	28	.2292	72	.7708
4	.0134	96	.9866	29	2407	71	.7593
5	0187	95	.9813	30	.2523	70	.7477
6	.0245	94	.9755	31	.2640	69	.7360
7	.0308	93	.9692	32	.2759	68	.7241
8	.0375	92	.9625	33	.2878	67	.7122
9	.0446	91	.9554	34	.2998	66	.7002
10	.0520	90	.9480	35	.3119	65	.6881
11	.0598	89	.9402	36	.3241	64	.6750
12	.0680	88	.9320	37	.3364	63	.6636
13	.0764	87	9236	38	.3487	62	.6513
14	.0851	86	9149	39	.3611	61	,6389
15	.0941	85	9059	40	.3735	60	.6265
16	.1033	84	.8967	41	.3860	59	.6140
17	.1127	83	8873	42	.3986	58	.6014
18	.1224	82	.8776	43	.4112	57	.5888
19	.1323	81	.8677	44	.4238	56	.5762
20	.1424	80	8576	45	.4364	55	.5636
21	.1526	79	8474	46	.4491	54	.5509
22	.1631	78	.8369	47	.4618	53	.5382
23	.1737	77	.8263	48	.4745	52	.5250
24	.1845	76	.8155	49	.4873	51	.5127
25	.1955	75	.8045	50	.5000	50	.5000

The Use of the Table of Segments

Is to find the Ullage, or Quantity of Liquor remaining in a Cask, whose Axis is parallel to the Horizon, the Surface of the Liquor cutting the Heads of the Cask.

The RULE *is*;

To the wet or dry Inches of the Bung-diameter, add a competent Number of Cyphers; then divide it by the whole Diameter, the Quotient found in the Table under the Title V. S. gives a Segment; which multiplied by the whole Content of the Cask, the Product shews the Quantity of Liquor in the Cask, if the Dividend was the wet Inches, or the Ullage, if it was the dry.

Let there be a Cask in Form of a Cylinder, whose Bung-diameter is 29 Inches, the dry Part 13, and the wet 16, and the Content 80 Gallons; How many Gallons are wanting to fill the Cask?

Divide the dry Inches 13, by 29 the Bung-diameter, and the Quotient is 448; find the two first Figures .44 under V. S. and the Segment against it is .4238; to which add a proportional Part for the 8, and the whole Segment will be .4333; which multiplied by the Content of the Cask, the Product will be 34.664 Gallons; and so much the Cask wants of being full.

Note, If the Cask be in the Form of a Cylinder, or near that Figure, the Table will give the Ullage exact enough; but if it be a spheroidal Cask, then use the following Method.

1. By

1. By the Bung and Head-diameter, find such a mean Diameter as, you judge, will reduce the proposed Cask to a Cylinder, and then find its Content.

2. From the Bung-diameter subtract the mean Diameter, and take half the Difference.

3. From the wet Inches subtract the said Half difference; reserve this Difference, then use the Proportion:

As the mean Diameter is to 100
(the Diameter of the tabular Circle),
So is the reserv'd Difference
to a versed Sine in the Table.

Then, if the tabular Segment be multiplied into the Content (as before) the Product will be the Quantity of Liquor in the Cask.

Example. Let the Cask be the same as in Page 325, of the first Form, where the Bung-diameter is 32 Inches, and the mean Diameter 29.6, and the Content 97.4 Gallons; and suppose the wet Inches 19, to find the Quantity of Liquor in the Cask.

From	32	From	19
Subtr.	29.6	Subtr.	1.2
Rem.	1.4	Rem.	17.8 reserved.
Half	1.2		

29.6 : 100 :: 17.8 : .60, the V. S.

The Segment to 60 is .6265, which multiplied by 97.4, the Content, the Product is 61 Gallons, the Quantity of Liquor in the Cask.

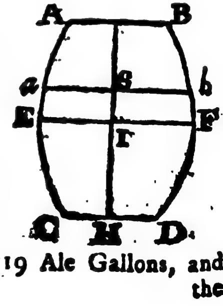
If the dry Inches have been given, by the same Method, you might have found the Ullage, or what the Cask wanted of being full.

To find what Quantity of Liquor is in a Cask, when its Axis is perpendicular to the Horizon; *viz.* when it stands upright upon one of its Heads.

To do this, you must know how to calculate the Area of any Circle, between the Bung and Head, whose Distance from the Bung, or Middle of the Cask, is given; which may be done by this Proportion.

As the Square of half the Length of the Cask is to the Difference between the Bung and Head-areas; so is the Square of any Circle's Distance from the Bung, to the Difference between the Bung-area and the Area of that Circle; *viz.* the Area of the Liquor's Surface.

Then, from the Bung-area, subtract one-third Part of the aforesaid Difference; *viz.* between the Bung-area and the Area of the Liquor's Surface: Multiply the Remainder by the Liquor's Distance from the Bung, and the Product will shew what Quantity of Liquor is either above or under half the Content of the Cask.



Example. Let us again suppose the Cask, in Page 325, whose Length is 40 Inches, Bung-diameter 32, and Head-diameter 24, and suppose the wet Inches, SH, 26 Inches.

The Square of half the Length is 400, the Distance of the Liquor's Surface from the Bung SI is 6, whose Square is 36; the Area of the Bung D 2.8519 Ale Gallons, and the

the Area of the Head D 1.6042; the Difference 1.2477. Then,

400 : 1.2477 :: 36 : .0751

One-third is = .0250

From	2,8519	Bung-area.
Subtr.	.0250	a Third of the Difference.
Rem.	2.8269	
	6	mult. Distance from the Bung.
	16.9614	Content above the Bung.
Add	48.7	half the Content of the Cask.
	65.66	the Quantity of Liquor in the Cask.

Problem IX.

Gauging of Malt.

TO find the Quantity of Malt in a Cistern, or upon a Floor.

First, Find the Area of the Base in Bushels, by multiplying the Length by the Breadth, and dividing the Product by 2150.42, or only by 2150; and multiply that Area by the mean Depth (How to take the mean Depth, see Problem II.) If the Base be circular or oval, divide by 2731 (see Problem I.)

Example.

Example. There is a Ciſtern, whoſe Length is 84 Inches, and Breadth 54 Inches, and the mean Depth is 43.6 Inches; What is the Content?

Multiply 84 by 54, and the Product is 4536; which divide by 2150, and the Quotient is 2.1097 Buſhels, the Area of the Bottom at 1 Inch deep; which multiplied by the Depth 43.6, the Product is 91.98 Buſhels, the Content.

Example. Suppoſe a Quantity of Malt upon a Floor, whoſe Length is 245 Inches, and the Breadth 184 Inches, and the mean Depth 5.6 Inches; How many Buſhels are there?

Multiply 245 by 114, and the Product is 45080; which divided by 2150, the Quotient is 20.967, the Area of the Baſe; which multiplied by the mean Depth, the Product is 117.4 Buſhels, the Content.

By the Sliding-Rule.

There is an inverted Line of Numbers upon ſome Sliding-Rules, marked with the Letter M, which was contrived purpoſely for Gauging of Malt; and there is a double Line of Numbers upon the Rule, and upon the Slider two double Lines of Numbers; all of theſe are of equal Radius, and all work together at once: Thus ſet the Length and Breadth againſt one another upon the inverted Line, and that which ſlides by it; then, on the other Edge of the Rule againſt the Depth, you will find the Content in Buſhels. Thus, in the firſt Example, ſet 54 upon the Slider againſt 84 upon the inverted Line; and then, againſt 43.6 upon the other Part of the Rule, is 91.98 upon the Slider.

Again; in the ſecond Example, ſet 184 upon the Slider to 245 upon the inverted Line; and againſt 5.6 upon the other Part of the Rule, is 117.4 upon the Slider.

§ II. *Of* LAND-MEASURING.

I SHALL not here give the whole Art of *Surveying*, but such practical Rules only as may be useful to the Country Grasiers and Farmers, whereby they may find the true Content of any Piece of Land, and that by the Chain only (and for want of that, with a Pole or Stick of half a Rod in Length.)

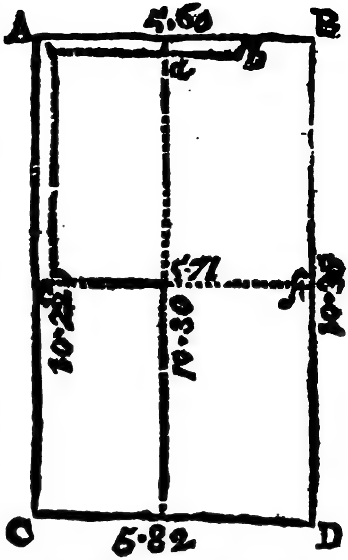
PROBLEM I.

To find the Content of a Piece of Land in the Form of a right-angled Parallelogram, or long Square, or what is something near that Form.

TO know whether any Angle in the Field be a Right-angle, or not, you may take a Piece of Board about 4 or 5 Inches broad, and an Inch thick, either round or square; and, with a Saw, cut two Kerfs, crossing each other at Right-angles; and bore a Hole in the Middle of the Back-side, to put it upon the End of a Stick. This will represent the Instrument called a Cross.

Suppose

Suppose you would observe the Angle A, to know whether it be a Right-angle (or near thereunto); prick up your Stick, with the Cross upon it, a little Distance from the Fence, as at *a*; and having set up two Marks, as at *b* and *c*, of equal Distance from the Fence, turn one of the Slits directly towards *b*; and then, if the other be directly pointing to *c*, it is a Right-angle.



To measure such a Piece of Ground as this Figure above: If you measure round, and add the opposite Sides together, and take half the Sum (if they be not equal); or else measure down about the Middle of the Length, and Middle of the Breadth; thus, the Side A B being measured, it will be 5.60 (that is, 5 Chains and 60 Links); and the opposite Side CD is 5 Chains 82 Links; the half Sum thereof is 5.71: And the Side BD is 10.38; and the Side AC 10.22; and the half Sum thereof is 10.30 (it will be the same Thing, if you measure about the Middle of the Length and Middle of the Breadth); then multiply this mean Length and mean Breadth together; *viz.* 10.30, by 5.71, and the Product is 58.8130; which divide by 10 (because 10 Square Chains is an Acre) by removing the separating Point one Place towards the Left-

Left-hand, and it will be 5.88130; that is, 5 Acres and .88130 Parts; which multiply by 4, and prick off 5 Places, and it will be 3.52520; which 3 towards the Left-hand are 3 Rods; then multiply the decimal Parts by 40, and prick off 5 Places, and it will be 21.00800; which 21 towards the Left-hand are 21 Perches.

	A.	R.	P.
So the whole Content is ———	5	3	21

See the Work.

```
 5.71
 10.30
------
 17130
 571
------
 5.88130          A. R. P.
       4          5  3  21
-------
 3.52520
      40
--------
 21.00800
```

Note, The Chain here made use of, is 4 Poles, or Rods, in Length; the whole Chain being 100 Links.

But, because every Man that may have Occasion to measure a Piece of Land, can't procure a Chain, I will therefore shew how you may measure a Piece of Land only with a Stick of half a Rod in Length; that is, 8 Feet and 3 Inches; which Stick divide into five equal Parts, so will the whole Rod be divided into ten Parts, and will thereby be adapted to Decimal Arithmetic.

But, because each of those Parts of the Stick are something large (each Part being 19 Inches and 8 Tenths) it will be necessary to take your Dimensions to half of one of those Parts; and then, for that half Part, set 5 in the Place of Seconds, thus, suppose 3 Parts and a half, set it down thus, .35.

PROBLEM II.

LET us suppose a Field in the Form of a long Square, whose Length is 45 Rods 5 Parts and a half, and the Breadth 31 Rods 4 Parts and a half; What is the Content?

Multiply the Length and Breadth together, and divide the Product by 160 (because 160 Square Rods are an Acre) and the Quotient is Acres.

$$\begin{array}{r} 45.55 \\ 31.45 \\ \hline 22775 \\ 18220 \\ 4555 \\ 13665 \\ \hline 1432.5475 \end{array}$$

16|0)143|2(8
128

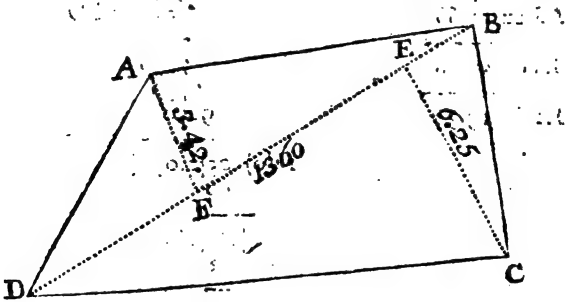
4|0)15|2(3
12

32

A. R. P.
Facit 8 3 32

PROBLEM III.

SUppose a Piece of Ground in the Form of a Trapezium; the Diagonal B D 13 Chains 60 Links, the Perpendicular C E 6 Chains 25 Links, and the Perpendicular A F 3 Chains 42 Links; What is the Content?



Multiply the Diagonal by half the Sum of the Perpendiculars. See Sect. VI. of Chap. I. Part II.

CE = 6.25
AF = 3.42

Sum 9.67

Half 4.83

13.60 = BD
4.83

4080
10880
5440

6.56880
4

2 227520
40

11.09800

A. R. P.
Facit 6 2 11

By Rods, thus;

CE = 25 Rods.
AF = 13.68

Sum 38.68

Half 19.34

19.34
554 = BD

7736
7736
9670

16|0)105|2.096(6
96

4|0)9|2(2
8

12

A. R. P.
Facit 6 2 12

To

To take the Dimensions of the Field.

Begin at the Angle B, and measure in a direct Line towards D; but when you come at E, set up your Cross, and direct one of the Slits to D, and then look through the other Slit, and if it exactly hits the Angle C, then are you just in the Place where the Perpendicular will fall; but if it does not exactly hit the Point, move backwards and forwards till it does so; then measure the Perpendicular, and set down the Chains and Links, or the Rods and Parts; then continue your Measure towards D; but when you come to F, set up your Cross, and try (as is above directed), whether you be in the Place where the Perpendicular will fall. Then measure the Perpendicular AF, and set down the Chain and Links, or Rods and Parts; then continue your Measure to D, and set down the Measure of the whole Diagonal. This Way of measuring is very exact and true; but the common Way used by the Graziers and Farmers, is to measure round the Field, and to take half the Sum of the opposite Sides for a mean Side; but the last mentioned Piece of Ground, being measured so, will come to

A. R. P. R. P.
7 0 22, which is 2 10 more than the Truth.

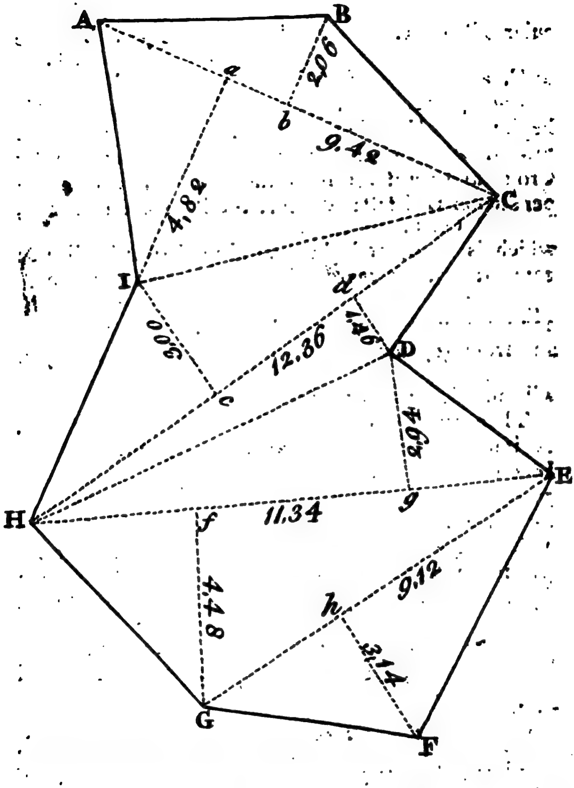
PROBLEM IV.

How to measure an irregular Field.

THE Way to measure irregular Land, is to divide it into Trapeziums and Triangles, thus:

First, view over the Field, and set up Marks at every Angle, and by those Marks you may see where to have a Trapezium, as ABCI in the following Figure.

Then



Then begin and measure in a direct Line from A towards C; but when you come to (a), set up your Cross, and try whether you be in a Square to I (as is before directed); and then measure the Perpendicular

Ch. L.

a I, which is 4.82; then measure forward again towards C, but when you come to (b) set up your Cross,

Cross, and try whether you be in the Place where the Perpendicular will fall; then measure the Perpendicular bB, which is Ch. L. 2.06; then continue your Measure to C, and you will find the whole Diagonal Ch. L. 9.42.

Then proceed to measure the Trapezium CDHI, beginning at C, and measuring along the diagonal Line towards A; but when you come at (d), set up your Cross, and try if you be in the Place where the Perpendicular will fall: Measure the Perpendicular dD, which is Ch. L. 1.46, and then measure forward till you come at (c), and there, with your Cross, try if you be right in the Place where the Perpendicular will fall, and measure the Perpendicular cI, which is 3 Chains; and from (c) continue your Measure to H, and you will find the whole Diagonal Ch. L. 12.36.

Then proceed to measure the Trapezium HGED, beginning at H, and measuring along the diagonal Line towards E; but when you come to (f) try with your Cross, if you be in the Place where the Perpendicular will fall; and measure the Perpendicular fG, which is 4.48; then continue on your Measure from (f) till you come to (g), and there try if you be in a Square with the Perpendicular gD; and measure the said Perpendicular, which is Ch. L. 2.94; then measure on from (g) to E, and you will find the whole Diagonal to be Ch. L. 11.34.

Then measure the Triangle EFG, beginning at E, and measuring along the Base EG, till you come at (h), and there with your Cross try if you be in the Place where the Perpendicular will fall; and measure the Perpendicular hF, which is Ch. L. 3.14, continue your Measure to G, and you will find the whole Base to be Ch. L. 9.12; so you have finished your whole Field.

I have

I have been the larger upon the Explanation of the Problem, because most Grounds lie in such irregular Forms.

Cast up the three Trapeziums severally, and also the Triangle; and add all the several Areas together into one Sum, which will be the Area of the whole irregular Plot.

See the Work.

bB = 2.06		9.42	See Sect. VI. Chap. I. Part II.
aI = 4.82		3.44	
Sum	6.88	3768	
		3768	
Half	3.44	2826	
		3.24048 = Area of ABCI.	

dD = 1.46		12.36
eI = 3.00		2.23
Sum	4.46	3708
		2472
Half	2.23	2472
		2.75628 = Area of CIHD.

fG = 4.48		11.34
gD = 2.94		3.71
Sum	7.42	1134
		7938
Half	3.71	3402
		4.20714 = Area of HGED.

Base

See Sect. V. Chap. I. Part II.

Base	= 9.12
Half	= 4.56
Perpend.	3.14
	1824
	456
	1368
	1.43184 = Area of the Trian. EFG.
	3.24048 = Area of ABCI.
	2.75628 = Area of CIHD.
	4.20714 = Area of HGED.
Sum	11.63574 = Area of the Whole.
	4
	2.54296
	40
	21.71840

A. R. P.

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F I N I S.

A CALCULATION of FOREIGN EXCHANGES, as tranſacted on the Royal Exchange of London; or, Tables, ſhewing at once, or by a few Additions, any Sum of Engliſh Money reduced into Foreign Species, and likewiſe any Sums of Foreign Species reduced into Engliſh Money, by Way of Exchange, at the ſeveral Prices, as from Time to Time the Exchange may Riſe or Fall. By EDWARD OLDENBURGH, Merchant.

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A Table of References to all the Arguments and References of the Lord Chief Juſtice HOLT; in the ſeveral Volumes of the Reports.

By GILES JACOB, Gent.